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Watershed Management
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DIVISION OF WATERSHED MANAGEMENT RESEARCH

Semiannual Report

U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

April - September 1957

FOR IN-SERVICE USE ONLY

SEMIANNUAL REPORT
Division of Watershed Management Research
April - September 1957

Washington Office

General functional inspections and field meetings took Storey and Frank to the California, Lake States, Rocky Mountain, Northeastern, and Southern Stations during the period.

Storey presented the recommendations of the Division for expanded or new research to the Forest Research Advisory Committee at its meeting in Ogden during the latter part of September. All were approved.

Storey, working in collaboration with Gordon Salmond, has given a good deal of time to the development of national forest soil survey procedures and starting of pilot testing of soil surveys. Retzer has been entirely in the field getting work initiated, training soils people and developing programs for local cooperation.

Storey and Frank have put in considerable time and effort working with other Research Divisions and Personnel Management in developing new standards for the Civil Service Research Forester Series. Detailed recommendations have also been made for revised standards in a new Soil Scientist Series.

We prepared a second report for inclusion in the ARS reply to the Soil Conservation Service Research Needs report. Items on which progress was indicated include runoff and water yields, especially peak flows and sediment production. It was gratifying to be able to list 23 publications since the previous report was submitted.

During the course of his Southern Station inspection, Frank visited the ARS sedimentation project at Oxford, Mississippi.

Some slight progress has been made by the Department Committee in meeting deficiencies in translations of Russian scientific literature. As a start, the Library plans to employ two persons for this purpose. (It may be that recent events will stimulate action towards a more adequate program, at least we hope so.) An AGU committee has also looked into the question of stepped-up translations of Russian literature and has distributed a questionnaire to ascertain the interests of various agencies and organizations in subscribing regularly to a translation service. In the interim, arrangements have been made for beginning work in several phases of geophysics, particularly hydrology. Frank served as a member of this committee in addition to being on the Department Committee.

Frank prepared a statement on the watershed management phase of the section on research for the new Forest Service Manual.

(Over)

A Washington Office family meeting in September featured watershed management. Schipull spoke on the action aspects and Frank on the research aspects. Following this talk the movie "Water for the West" was shown.

A statement was prepared for an FAO publication on the watershed management research program. Circumstances required this statement to be based on the former work and line project system. However, the next revision will follow the present revised scheme.

Staff Addition: Clark E. Holscher is our newest--and highly welcome--staff member. Previous to joining us he was associated with FAO's Forestry Division in Rome as Chief of the Forest Conservation Section, and still more previously he was attached to the NW Station as a range management researcher.

Attention: Please note the October issue, AGU Transactions, pages 797-798, concerning the next annual meeting on May 5-7, 1958. Proposals for papers on hydrology can be sent to Bernard Frank, Chairman of the Hydrology Section Program Committee.

Publications

"Forest Practices and Productivity," by Harper, Frank, and McQuilkin, in SOILS, Yearbook of Agriculture 1957.

"Water," by Bernard Frank, National Wildlife Federation Leaflet.

SEMIANNUAL REPORT

Division of Watershed Management Research
California Forest and Range Experiment Station

May 1957 through September 1957

GENERAL

Snow management research, in cooperation with the California Department of Water Resources, completed its first year July 1, 1957. Twelve studies are underway and high Sierra field installations in the headwaters of the Kings, American, Yuba, and Truckee rivers are producing needed snow management information. Full and part-time technical staff includes seven foresters and three meteorologists.

The San Dimas Advisory Committee organized last spring held its first meeting on April 25 and 26. Nine of the fifteen members were present, and three others sent representatives. The meeting included a half-day field trip over the San Dimas Forest, an over-night stay at Tanbark Flat headquarters, followed by a half day of discussion concerning current and proposed research projects. A statement titled "Program of Watershed Management Research in Southern California" prepared for the meeting was used as a guide for the discussion. This was primarily an orientation meeting for the new group. It was recommended that future meetings be limited to certain projects to provide time for more detailed discussion than was possible at this initial session. Our former colleague, Dr. Paul Zinke, Professor of Watershed Management, School of Forestry, University of California, was elected chairman of the Committee.

This has been a period of inspections at San Dimas. Safety Inspectors Seth Jackson of the Washington Office, H. E. Branaugh of Region 5, and F. W. Bacon of the Station, gave us a once-over on July 10. Herb Storey reviewed research plans with the staff during the last week of July. W. L. Graves and J. C. Iler of the Washington Office, D. R. Ball of Region 5, and F. W. Bacon visited Glendora for an operations inspection on August 16. The G.I.I. team of Assistant Chief Crafts and McKennan of the Washington Office, with Regional Forester Connaughton and Director Arnold spent the afternoon of September 18 reviewing plans for vegetation treatments to increase water yield in Bell Canyon or Monroe Canyon.

The Central Sierra Snow Laboratory had its share of inspections, too. Inspectors from the Department of Water Resources included William Berry, William Fairbanks, Carl Meyer, and Wayne McRostie; and from the Forest Service, Herb Storey and the Pacific N. W. Station Watershed Management Research Division.

All in Watershed Management Research will be glad to hear that gifts and pledges to the E. A. Colman Memorial Fund for aiding graduate students in Watershed Management have reached nearly $10,000. Another conditional donation of $5,000 has been pledged.

Research at San Dimas was broadened during the summer with the arrival of two permanent Fire Research staff men. Craig Chandler will coordinate fire research in southern California, and will assist in studies on the effects of brushland conversion for fire control purposes. William Carter will conduct operations research on the initial attack methods on fires, aimed at integrating newer techniques such as water dropping by aircraft into initial attack plans.

Eula B. "Skip" Goodwin received a $150 incentive award September 18 for his superior services on the San Dimas Forest. Goodwin, a 30-year Navy veteran, has for the past 10 years been in charge of the Tanbark Flat field headquarters, and also has assisted in conducting research projects. Director Arnold, in making the award, emphasized Skip's personal contribution through his friendliness in caring for official visitors, and his willingness to accept responsibilities and perform duties beyond his regular assignments.

PERSONNEL

Johnnie Andre, a recent graduate of Oregon State College, with a MS in Soils has joined the Snow Hydrology Group to study the erodibility of California wildland soils. Cliff Mansfield, transferred from the Weather Bureau, Portland, Oregon, will be in charge of instrument development in the Snow Hydrology Section. Allan J. West, a recent graduate of the University of California, with a MS in Watershed Management is at the Snow Lab. working on winter evapo-trans-piration and also on the heat and snow study.

Anderson was one of three U. S. Department of Agriculture men selected to attend the management Intern Program for research personnel in Washington D. C., September 9-20, 1957.

Clark Gleason has recently joined the Snow Hydrology Staff. Gleason will head up operation of the experimental watersheds and conduct related studies in hydrologic processes.

Joseph E. Linder, Forestry Aid, became a full time research man on May 19. Joe had worked with us several winter seasons, and was Fire Guard at Tanbark Flat during summers before transferring to San Dimas from the Mt. Baldy District, Angeles National Forest.

Edwin O. Smith was appointed on May 19, 1957 to fill the vacancy left by the late Frank Mathys at Glendora.

Geoffrey Coleman transferred from San Dimas to administration on July 28, 1957. Jeff is now Assistant Ranger on the Valyermo District, Angeles National Forest.

Miss Mary Louise Dutton, Statistical Clerk, retired on May 31 after nearly 10 years at the Glendora office.

Helen Bell and Mary Weaver were employed as temporary Statistical Clerks at San Dimas during the summer.

PUBLICATIONS

Manuscripts Published

"Watershed Management Considerations for Sanitation-Salvage Logging in Southern California" by Walt Hopkins, CF&RES, Forest Research Note: No. 121, pp 1-4, April 1957.

"Anti-freezing Hoods for V-notch Weirs" by Carl O. Johannessen, Jour. Forest. 55(8):590, 1957. The design given was for 90° V-notch weirs. Some recent tests indicate that for 120° V-notch weirs the tail apron should be about 3 inches longer for the same performance.

"Operation Wet-Blanket Gets Underway" by H. W. Anderson. Abstracted in Trans. Amer. Geophys. Union 38(3):414, 1957.

"Changes in Burning Terminology", by A. W. Sampson and Clark H. Gleason. Jour. Range Management 10(3):i. May 1957. Published as a Letter to the Editor, unfortunately with important typographical errors; see rather Jour. Forest 55(3):219, 1957.

"Reconnaissance Methods of Measuring Erosion", by Clark H. Gleason. Jour. Soil and Water Conservation 12(3):105-107, May, 1957. (Described briefly in previous report.)

An article describing the San Dimas Maximum Waterstage Indicator developed by L. A. Andrews, was presented in Engineering News-Record June 13, 1957.

Manuscripts Accepted for Publication

"San Dimas Soil-Core Sampler," by L. A. Andrews and W. M. Broadfoot. To appear in Soil Science in June or July 1958.

"Relating Sediment Yield to Watershed Variables", by H. W. Anderson. To appear in December, 1957, issue of Trans. Amer. Geophys. Union.

"Snow on Forested Slopes", by H. W. Anderson and T. H. Pagenhart. To appear in Proc. Western Snow Conf., 1957.

"New Meteorological and Snow Studies in Central Sierra", by K. J. Walsh. To appear Proc. Western Snow Conf., 1957.

"Wind During Snowfall Hours at CSSL", by Arnold Court. To appear in Proc. Western Snow Conf., 1957.

"Snow Surveying from the Snow Surveyors Side", by P. J. Wyckoff. To appear in Proc. Western Ssow Conf., 1957.

CURRENT RESEARCH

San Dimas Experimental Forest

Watershed Management Tests to Increase Water Yield

Two San Dimas watersheds are being placed under intensive management.

Basic studies of watershed management on the San Dimas Experimental Forest have shown that there are important differences in rates and amounts of water use by brush, grass, and tree species in the mountain areas of southern California. This is particularly true of vegetation occupying soils over 4 feet deep and soils along channels with a perennial surface or subsurface water supply. Manipulation of vegetation from these mountain areas will be tested on a watershed basis. Objectives will be to (1) test promising methods of increasing water yield by vegetation manipulation and (2) determine the magnitude and source of increased water yield in relation to treatments applied and to the associated physiographic characteristics of the watershed.

The study includes stream channel and side slope treatment. The trees and shrubs of the riparian-woodland in and along the channels of Monroe Canyon (875 acres) in the Big Dalton drainage will be killed. The adjoining Volfe Canyon (740 acres) will be maintained as the untreated control watershed. The brush and forb vegetation on side slope areas with soils of 30 or more inches in depth in one of the Bell watersheds (35-100 acres each) will also be killed. Another adjoining Bell watershed will serve as the control.

Rainfall and streamflow records obtained from each of the watersheds during the last 20 years supplemented by soil moisture sampling to be conducted in the treated and control watersheds will be used along with sediment records from the small watersheds in evaluating the effects of the treatments. A test of an opaque plastic sheeting laid over the treated streamside area above the high water level to further reduce evaporative loss from the canyon bottom zone is also to be tested this winter. If the side slope vegetation treatment in the small Bell watershed is found to be practical it will be applied to slopes of the Monroe Canyon watershed in which the riparian-woodland has been treated, after this latter treatment has been evaluated.

Lysimeters

A preliminary investigation was started in April to determine the effects of defoliation on water use by Ceanothus crassifolius and Rhus laurina. Since then, 27 small lysimeters with soil 24 inches deep, (averaging 330 pounds of soil each) containing single plants, and two containing bare soil have been weighed on the first of each month. After each weighing the leaves of two plants of each species were plucked by hand. Records were maintained of monthly weights of lysimeters and of observations of treated and untreated plants. Evapotranspiration was calculated from soil moisture storage and precipitation data. The effect of defoliating Rhus laurina on evapotranspiration is indicated in the following tabulation:

Treatment of vegetation	Evapotranspiration use				Total for period
	May	June	July	August	
	Inches depth				
None (bare soil)	1.85	1.38	0.80	0.22	4.25
None (full foliage)	2.30	4.49	0.56	0.24	7.59
May defoliation	1.96 1/	3.27	2.23	0.13	7.59
June defoliation	2.17	2.28	2.69	0.33	7.47
July defoliation	2.30	4.05	0.89	0.24	7.48
August defoliation	1.85	4.70	0.81	0.21	7.57

1/ Underlined values are for defoliated plants.

These lysimeter data show that for this 2-foot deep soil, (1) defoliation changes the rate of evapotranspiration use, but has little effect upon total seasonal use; (2) June defoliation was most effective in extending the period of evapotranspiration use by R. laurina into the summer months; and (3) evapotranspiration use during August was limited by the supply of available water to a value near that of evaporation from the bare soil surface.

At the end of September, lysimeter-grown R. laurina and C. crassifolius plants defoliated in May and June have succulent twigs and a few green leaves. All other lysimeter plants appear to be dying from desiccation, having no green parts except the woody main stems.

On the first of each month R. laurina and C. crassifolius plants growing in natural surroundings in the vicinity of the lysimeters were defoliated with SO_2 gas. These treatments were designed to find out if the effects of defoliation on plants in the lysimeters were the consequences of an artificial environment and a limited water supply. Treated plants showed physiological responses similar to those obtained in lysimeters but to a lesser degree, presumably because of more available water. Regrowth of leaves following defoliation was quicker, more complete, and occurred at later dates. In general, total amounts of new leaves decreased as the dry season advanced.

Sulfur dioxide was found to be a cheap, easily applied, and universally effective defoliant for chaparral species. Concentrations of 1 cc. of liquid SO_2 per 15 cubic feet air (approximately 1,000 ppm.) gave a complete leaf kill when applied for 10 minutes to shrubs under a plastic car cover. There was no apparent damage to buds or twigs. Recovery started in 2 weeks, and leaves continued to develop for another month.

A work plan has been prepared to further investigate defoliation as a watershed management technique. Pairs of large lysimeters with soil 6 feet deep, (64 tons of soil each) containing similar plants will be irrigated to supplement natural rainfall and produce seepage during the winter and spring. The vegetation in one tank of each pair will be defoliated. The effect of the treatment will be

measured by comparing the quantities and durations of flows from and the soil moisture in defoliated and untreated tanks. A second phase of this study will measure certain of the gross responses of chaparral plants to a series of defoliation treatments.

Rainfall Disposition Plots

Further information of the effects on evapotranspiration of defoliating mature chaparral species has been obtained from the Tanbark Flat rainfall disposition plots. Evapotranspiration from these oak-chaparral plots has amounted to nearly all of the available water throughout the 12-foot soil profile for each of the 5 years of record. A foliage spray of 2,4,5-T at a heavy rate was applied on November 6, 1956. Three subsequent partial retreatments have killed most of the brush and greatly reduced its transpiration use.

A comparison of evapotranspiration from the brush plots for two comparable periods before and after spraying is shown below:

Period	Soil moisture storage start of period	Rainfall during period	Total 1/	Soil Moisture end of period	E-T	Cumulative E-T	Cumulative rainfall lost by E-T
	Inches						Percent
Wetting 11/8/55-5/12/56	12.0	20.1	32.1	22.5	9.6	9.6	47.8
Drying 5/12/56-8/27/56	22.5	0.1	22.6	13.7	8.9	18.5	2/ 91.6
2,4,5-T applied 11/6/56							
Wetting 11/30/56-5/28/57	12.5	19.4	31.9	26.7	5.2	5.2	26.8
Drying 5/28/57-8/27/57	26.7	0.4	27.1	23.9	3.2	8.4	42.4

1/ Soil moisture in storage plus rainfall. No runoff occurred in either year.

2/ Total use to end of dry season (11/30/56) was 97.5 percent of rainfall.

CMU Pilot Test

The use of a soil sterilant has been considered as a treatment to drastically reduced soil moisture use by riparian-woodland vegetation. CMU was chosen for testing as a single application should produce long lasting phytotoxic effects on a wide range of plants. Plots were laid out under an open stand of Quercus agrifolia having a scattered shrub understory and a dense herbaceous ground cover. Applications of CMU were made on August 8 at rates of 10, 25, and 40 pounds per acre. Irrigation brought soil moisture from near wilting point to field capacity for a depth of 8 feet. Summer dormancy was not broken until September 14 when new growth had started on the broad leaved ground cover. Three days later the leaves of these plants on all plots were dying back from the tips. On September 27 a less widespread browning of leaves had occurred on some of the shrub understory on Plot 2 (25 pounds per acre). So far, CMU has had no visible effect on the Q. agrifolia overstory.

Soil Movement Study

Data and observations of the soil movement study in the Los Angeles River watershed through June 1957 have been summarized and a report is in preparation.

Snow Studies

A set of 4 experimental watersheds in the mixed conifer type were selected in the Onion Creek drainage just south of the Snow Lab. Dams about 14 feet high, with 120° V-notch weirs 3-1/2 to 4-1/2 feet in height are being installed. Two dams are in; we are racing the weather for the other two. Concomitant measurements of meteorological, snow, interception, soil moisture and erosion processes are planned in these watersheds.

In the study of heat and snow in forest and openings, 29 forest openings and 26 forest density sites were selected. The forest openings range from less than one to more than 8 times the tree heights. Forest density sites are distributed throughout all density classes. The sites were chosen to have a good distribution of slopes, aspects, and tree heights. All are located near the Snow Lab. About 24 sampling points were selected at each site, on a randomly located grid. Measurements of snow depth and density and of the incoming and outgoing all-wave radiation at each point at approximately one month intervals are planned for most of the points.

Suspended sediment sampling was started of the flow of Castle Creek near the CSSL Headquarters (D.A. = 3.96 sq. mi.). Periodic samples are planned over a range of flow conditions. A small basin will serve to catch the bed load in all except heavy flood years or extreme accelerated bedload discharge.

Summer evapotranspiration losses were measured at 75 different forest sites. The four major soil types at the Snow Lab and various slope and forest conditions were sampled. Field capacity storage was determined by taking soil moisture sample profiles at each site, soon after the snow disappeared last spring. Change in storage between that measurement and a late fall measurement, plus correction for precipitation, will be a measure of the summer evapotranspiration loss.

On the Sierra east side a cooperative study has been started with the Department of Zoology of the University of California in the Sagehen watershed. Intensive studies of fishlife have been under way there for several years. Studies of watershed management effects on streamflow, sediment, and the resultant effects on fish life are planned.

A cooperative study with our Forest Management Research Division got under way at the Swain Mountain Experimental Forest. This forest is a volcanic cone, with old growth stands of red and white fir, fairly typical of these stands on the Sierra east side.

The stands will be cut in various patterns of strips and blocks in the coming years. Pre-cut measurements of snow accumulation and melt will start this winter in areas planned for cutting next summer.

MEETINGS

April 16.--Patric discussed congervation and watershed management before a Glendora PTA group.

May 9.--Sinclair talked to the Glendora Lions Club on watershed research on the San Dimas Experimental Forest.

May 16-17.--Several talks were given in connection with meetings of the California Board of Forestry and Field Day at Visalia. Rowe presented "Watershed Management Research at the San Dimas Experimental Forest and Some Applications of Results to Foothill Problems", at the meeting and on a radio program. Gleason spoke on erosion indicators, and Anderson spoke on snow management research.

Anderson also spoke on snow management research on one TV and two radio programs.

June 7.--Merriam took part in a panel discussion at the Southern California Section, Society of American Foresters, at Riverside. General topic was "Problems of Foresters in Southern California."

June 20.--Merriam presented a slide talk on "Effects of Mountain Watersheds on Water Supplies" to the Bi-County Agricultural Round Table.

August 28-31.--Gleason was "Greetings" chairman at Conservation Society of America at Asilomar, California.

September 3-14.--Hamilton attended the Eleventh General Assembly of the International Union of Geodesy and Geophysics in Toronto. He served as a member of the National Academy of Sciences National Research Council Delegation to the International Association of Scientific Hydrology.

COOPERATION

U. S. Weather Bureau, San Francisco.--Soil temperatures from Colman units in the grass-covered rainfall disposition plots are being furnished monthly for publication in Climatological Data, California. Temperatures from depths to 138 inches are included and are the only soil temperature data at depths greater than 18 inches currently published in California.

Agricultural Research Service, Soil and Water Conservation Research Division, Brushland, Texas.--Furnished information on the location and years of record for recording rain gages at the San Dimas Experimental Forest and the Central Sierra Snow Laboratory. Similar data of radiation measurements at the Central Sierra Snow Laboratory were also furnished.

School of Tropical and Preventive Medicine, Loma Linda, California.--Data on climatic patterns and flora of the San Dimas Experimental Forest have been requested and supplied.

City of Azusa, California.--William H. Kirk, City Engineer and members of his staff conferred with Rowe. San Dimas Research Center furnished rainfall intensity records for Glendora for all storms 1946-47 through 1949-50 for preliminary planning concerned with the establishment of a city-wide storm drain and sewer system.

City of Glendale, California.--Mr. Sheldon Rosa of the Engineering Office of the Planning Division conferred with Rowe and Reimann on the problems of drainage and slope stabilization on new roads and housing tracts being developed in the foothill areas of the city.

Rocky Mountain Forest and Range Experiment Station.--Horton was furnished rainfall data and San Dimas Experimental Forest minimum rain gage network analysis.

Pasadena Star-News, Pasadena, California.--Mrs. Blythe Mendenhall was given material for a newspaper article on the Tanbark rainfall disposition plots.

Angeles National Forest, Mt. Baldy District.--Fire plan map for Tanbark Flat area was prepared.

Los Angeles County Flood Control District, Debris Reduction Study Group.--R. W. Ferrell conferred with Rowe concerning determination of watershed wetness during winter periods with alternate wetting and drying and the effects of antecedent wetness on peak discharge and erosion from small watersheds during moderate and heavy storms.

Angeles National Forest.--Sinclair and Rowe received and prepared comments for M. R. Howlett, Forest Engineer on "Report of Cooks Canyon Channel Stabilization Project."

State Department of Water Resources.--Robert Whiting and Carl Meyer discussed with Anderson estimation of the effects on consumptive use of conversions of forests to homesites in the Lake Tahoe area.

U. S. Geological Survey.--Wm. Dean inspected proposed dam sites in the Onion Creek watersheds and gave us many helpful suggestions.

Bureau of Reclamation.--Richard Rongey and Dr. Ralph Cole together with Jack Lawrence of the Dept. of Water Resources, discussed with Anderson on natural water loss measurements in their experimental watershed in Shasta County.

VISITORS

During the past six months there were 144 visitors to the San Dimas Research Center. Forty-four of them came as student groups, and there were 20 from Afghanistan, Australia, Formosa, Great Britain, India, Iran, Pakistan, Sicily, South Africa, Spain, Turkey, and Yugoslavia.

Berkeley visitors include Forest Sterns from the Vicksburg Research Center, Warren Murphy from the WO, Cliff Shopmeyer from the Lake States, and Mr. Menne from Australia.

INFORMATION REQUESTED

San Dimas Research Center

Comments and suggestions, particularly with regard to the proposed treatments in our Big Dalton watersheds are invited. (See CURRENT RESEARCH). We particularly need information on the following points:

1. How the neutron-scattering technique for soil moisture determination is working out in wild land soils.

2. Techniques for measuring areal evapotranspiration on small areas. We need to know whether or not our deep-rooted brush species receive a measurable supply of water from their roots in fractured rock.

3. Any experience with polyethylene or vinyl-type plastic sheeting in wild land areas such as application methods, life expectancy, etc.

TIPS YOU MIGHT NOT HAVE HEARD

Don't use pure anti-freeze solution, such as Preston in rain gages, sink drains, etc. Add water to bring the mixture near the eutectic point which has a considerably lower freezing point. See manufacturers specifications.

For preventing evaporation from rain and snow storage gages transformer oil is highly effective, will not freeze, boils at over 212 degrees F., and costs only 40 cents per gallon (Shell Co. "Dial" transformer oil).

SEMIANNUAL REPORT OF WATERSHED MANAGEMENT RESEARCH

CENTRAL STATES FOREST EXPERIMENT STATION

April 1, 1957 - September 30, 1957

General

Plans for expanding the Watershed Research Program continued. A student was headquartered during the summer at the Soil and Water Conservation Research Station, Coshocton, Ohio. Lawrence Hill, a major in Watershed Management at the University of Michigan did an outstanding job in arranging data for analysis, collecting field data and photographs, and guiding visitors around the forest watersheds.

Arrangements were made with the Station's Forest Survey Unit to collect watershed information during the Missouri survey. Data is to be coded by watershed drainages indicated on FIARBC River Basin maps, in addition to county and regular survey district units. Plans are to follow field procedures developed for the Arkansas Survey by the Southern Station's Conference at Hot Springs, Arkansas last May.

Johnson attended the Soil Conservation Society of America meeting at Asilomar, California, August 28-31, and took this opportunity to pay a brief visit at the San Dimas Research Center.

Johnson spent most of the summer in the field getting acquainted with Station territory, and working with National Forest technicians. Cooperation with NFA included the following:

1. Wayne-Hoosier National Forest, water quality and sedimentation problem at the Lake Vesuvius recreational area.

2. Region 9 - Opportunities of using National Forest Lands in southeastern Iowa for research and demonstration.

3. Region 7 and Cumberland National Forest - Mine acid discharge survey and study areas for evaluating effects of strip mining.

4. Bernard Frank started a three week general integrating inspection of the Division on September 30. Arrangements were made to visit all Research Centers at the Station. Fall is the best season for visiting field installations in the Midwest. The combination of two Washington Office GFI's and a Station GII kept Johnson in the field for six weeks this fall.

Precipitation-runoff relations from small watersheds

Figure 1 illustrates the change in correlation coefficients for precipitation-runoff regressions calculated on a 12-month basis, but with different initial and final dates. It is apparent certain periods show a better relation than others. For example, the U.S.G.S. water year ranked low while a June 1-May 31 water year ranked highest. From these correlation coefficients it appears there is a greater consistency in watershed storage and flow in May and June than there is in the time and amount of minimum streamflow.

An inspection of records from the weighing lysimeters at Coshocton suggests data on soil moisture storage can improve correlation coefficients for nearby forested watersheds. We are planning additional analysis and refinements in our techniques as soon as a technician reports.

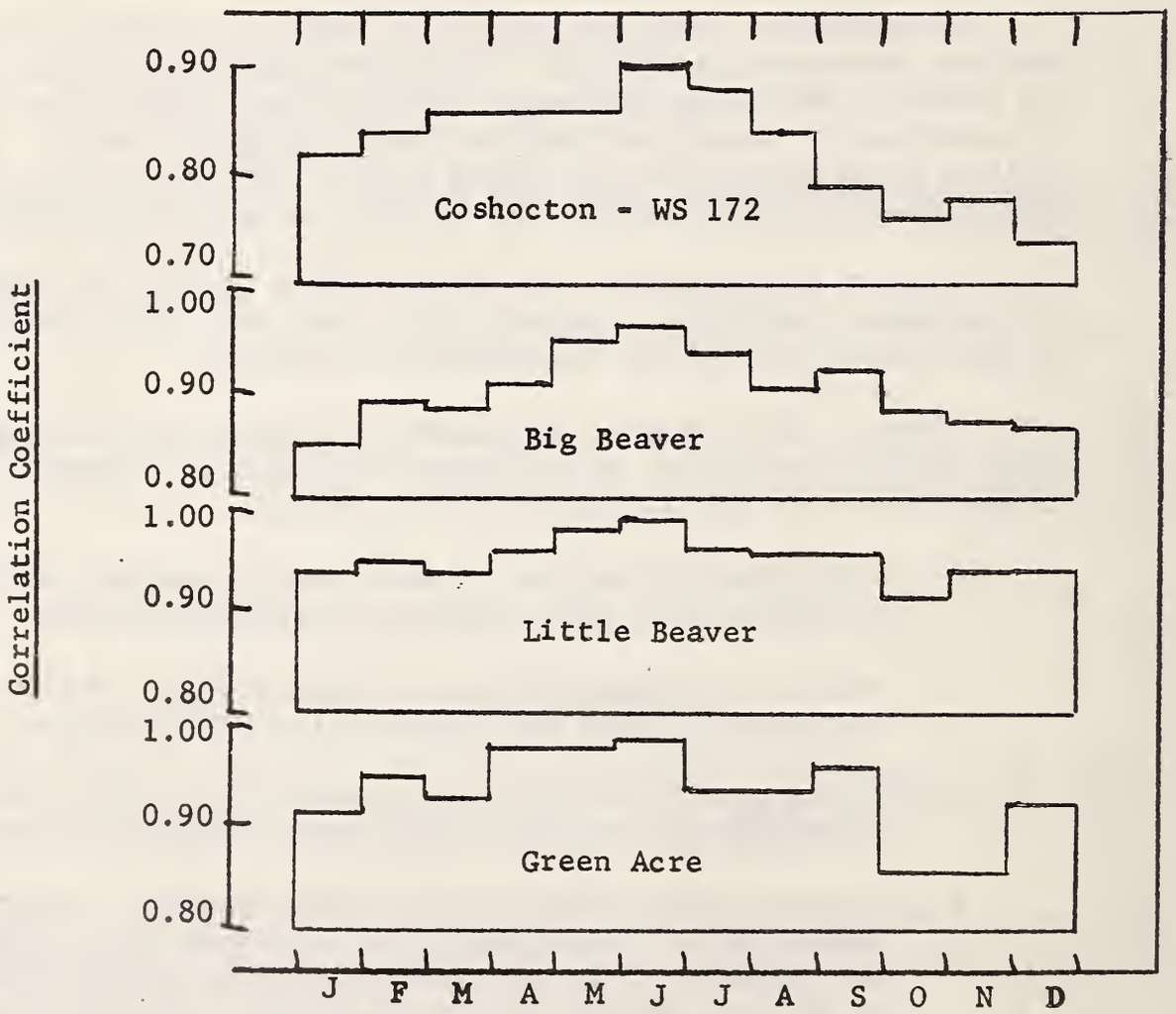


Figure 1.--Correlation coefficients for 12 month precipitation runoff regressions with different initial and final dates (the October coefficient is for the period October 1-September 30).

Columbia Research Center

by Ronald Whipkey

Three small watersheds near Rolla, Missouri have been selected for hydrologic analysis.

The objective is the determination of some hydrologic characteristics of variable-sized small watersheds under mixed land use in the Missouri Ozarks. The period of record is 1948-1955, with runoff data supplied by the U. S. Geological Survey, and precipitation data supplied by the U. S. Weather Bureau. The study has been approved by P. W. Fletcher, University of Missouri, as a Master of Science thesis project for R. Z. Whipkey.

Table 1 describes the three watersheds covered in this study.

Table 1.--Basin descriptions.

Basin area	Size	Land use	Topography	Geology	Soil type	Soil profile description
Green Acre Branch	0.622 sq. mi.	crops and pasture	rolling	lower Jefferson City Roubidoux*	Clarksville silt loam (also known as Ozark)	Surface relatively stone free, relatively deep
Little Beaver creek	6.41 sq.mi.	1/3 oak forest 2/3 crops and pasture	rolling to steep	Roubidoux sandstone Gasconade*	Clarksville gravelly loam	Surface extremely rocky, thin soil mantle
Beaver Creek	14.0 sq.mi.	2/3 oak forest, 1/3 crops and pasture	rolling to steep	Jefferson City dolomite Roubidoux	Lebanon silt loam Clarksville gravelly loam Clarksville stony loam Huntington gravelly silt loam	Stone free, claypan subsoil, surface relatively stone free, moderate depth, surface extremely rocky, thin soil mantle, colluvial and alluvial branch bottom

* Underlying geologic formation at the control.

Green Acre Branch is located in a good agricultural area and the soil is deep with good storage of available moisture. Little Beaver Creek drainages have a large proportion of thin, rocky agricultural soil--of the two, the agricultural soils of Beaver Creek are the poorest. Rock content of the soils of the latter two drainages varies from 25% to 65%.

The gages were originally installed by the U. S. Geological Survey at Rolla, Missouri in cooperation with the Missouri Highway Commission in order to study peakflows from small watersheds. The controls at the gages are essentially natural controls and flow is measured with the Price current meter (Pygmy and Standard). For these reasons, there was not a sensitive stage-discharge relation at the lower flows and the low ends of the rating curves may be weak. Below 0.2 C.S.M. on the depletion curves considerable scatter of the data was apparent.

Precipitation

An analysis of the precipitation and runoff data show the water year June 1-May 31 as having the highest degree of correlation.

The long time precipitation average for the Rolla, Missouri area is 43 inches annually. For the period 1948-1955 the three watersheds had an average of approximately 38 inches annually--the highest amounts recorded between May through August, and the lower amounts between November through February as shown in Table 2. Extremes for this period ranged from 20 inches to 52 inches. The period March through July gave the largest number of monthly storms and the period September through December the lowest number of monthly storms. There was quite a bit of scatter in this data; June, the wettest month, showed extremes of 18 storms in 1949 to 2 storms in 1953. October is normally a dry month, but 4 large storms in October 1949 gave an abnormally high precipitation for that month. This accounts for the obvious disruption of both the precipitation and runoff trends shown in Table 2.

Table 2.--Average precipitation and runoff - October 1948 through September 1955
(in inches)

Month	Green Acre Branch				Little Beaver Creek				Beaver Creek			
	Precip.	Run-off	Difference	Av. No. storms	Precip.	Run-off	Difference	Av. No. storms	Precip.	Run-off	Difference	Av. No. storms
June	4.53	1.21	3.32	9	5.36	1.78	3.58	10	4.18	1.33	2.85	9
July	3.13	.51	2.62	9	3.78	.70	3.08	9	3.03	.63	2.40	8
Aug.	4.35	.42	3.93	7	4.37	.43	3.94	8	4.25	.28	3.97	7
Sept.	2.58	.35	2.23	5	2.43	.45	1.98	5	2.65	.34	2.31	5
Oct.	3.58	1.04	2.54	6	3.98	1.44	2.54	6	3.95	1.28	2.67	6
Nov.	1.93	.42	1.51	4	1.94	.60	1.34	5	2.01	.57	1.44	5
Dec.	1.83	.41	1.42	6	1.81	.50	1.31	6	2.03	.68	1.35	6
Jan.	2.71	1.32	1.39	7	2.72	1.44	1.28	7	2.81	1.67	1.14	7
Feb.	2.57	1.30	1.27	7	2.35	1.44	.91	7	2.64	1.56	1.08	7
Mar.	3.13	1.40	1.73	9	3.24	1.91	1.33	9	3.24	2.05	1.19	10
Apr.	2.48	.76	1.72	8	2.79	1.29	1.50	8	2.49	1.20	1.29	7
May	4.78	.96	3.82	10	4.26	1.20	3.06	10	4.41	1.33	3.08	10
Total	37.60	10.10	27.50	87	39.03	13.18	25.85	90	37.69	12.92	24.77	87

Total Yields

The two larger watersheds show an annual average of 13 inches or runoff, while the smallest watershed shows an average runoff of 10 inches. All three watersheds have a similar seasonal distribution of runoff with 20% to 25% occurring between July through December, and 75% to 80% between January through June. Approximately 27% of the precipitation occurred as runoff on the smallest watershed, and 38% on the larger watersheds.

The lowest runoff usually occurs in September, and the highest runoff in March. Runoff generally begins to pick up in the middle of January. During April runoff declines--the growing season commences sometime in April.

Baseflow and Stormflow

Baseflow was separated from the stage hydrographs (following procedures described in Hydrology, Wisler and Brater, 1949), and the total daily discharges were broken into the components--storm runoff and non-storm runoff. Table 3 shows for the three watersheds approximately 7 inches of the total runoff occurred as stormflow. Baseflow, however, showed a difference between the small and the larger drainages; on the two larger drainages 6 inches ran off as baseflow, while only 2.5 inches occurred as baseflow on the smallest drainage. Percentagewise, approximately one-half the runoff of the two larger drainages occurred as storm runoff; whereas, approximately 75% was stormflow on the smallest drainage.

Stormflow was generally highest in June and lowest in November. Baseflow was generally highest in March and lowest in August.

Table 3.--Average storm runoff and non-storm runoff - October through September 1955 (in inches).

Month	Green Acre Branch		Little Beaver Creek		Beaver Creek	
	Runoff		Runoff		Runoff	
	Non-storm	Storm	Non-storm	Storm	Non-storm	Storm
June	0.13	1.08	0.48	1.30	0.41	0.92
July	.08	.43	.30	.40	.26	.37
Aug.	.02	.40	.16	.27	.16	.12
Sept.	.06	.29	.21	.24	.15	.19
Oct.	.12	.92	.36	1.08	.34	.94
Nov.	.19	.23	.41	.19	.38	.19
Dec.	.18	.23	.36	.14	.37	.31
Jan.	.36	.96	.77	.67	.70	.97
Feb.	.37	.93	.80	.64	.70	.86
Mar.	.61	.79	1.17	.74	1.09	.96
Apr.	.26	.50	.81	.48	.74	.46
May	.13	.83	.50	.70	.49	.84
Total	2.51	7.59	6.33	6.85	5.79	7.13

Ground Water Depletion and Storage

From daily discharge plottings, segments of the recession limbs four days after storms were picked off and depletion curves derived by the method suggested in S.E.F.E.S. Station Paper No. 68, Johnson and Dils, 1956.

Green Acre Branch depleted from 0.53 C.S.M. to 0 in 30 days, Little Beaver Creek from 1.30 C.S.M. to 0 in 45 days, and Beaver Creek from 1.12 C.S.M. to 0 in 50 days. Reference to Table 4 shows the largest watershed, while having the longest period of depletion, has a smaller initial storage value than the next largest.

Table 4.--Normal ground water depletions and storages - October through September 1955

Time (days)	Depletions: Green Acre Branch C.S.M.	Depletions: Little Beaver Creek C.S.M.	Depletions: Beaver Creek C.S.M.	Rate (C.S.M.)	Storages: Green Acre Branch inches	Storages: Little Beaver Creek inches	Storages: Beaver Creek inches
1	0.53	1.30	1.12	0.00	0.00	0.00	0.00
5	.30	.82	.75	.01	trace	trace	trace
10	.15	.47	.46	.02	trace	trace	.01-
15	.07	.27	.28	.04	.01	.01	.01
20	.03	.16	.17	.07	.02-	.02	.02
25	.02	.08	.10	.10	.02+	.03	.04
29	.01-	.06	.07	.20	.05	.06	.08
30	.00	.05	.06	.50	.14	.17	.19
35	--	.03	.04	.70	--	.24	.27
40	--	.02	.02	.90	--	.31	.35
44	--	.01	.02-	1.00	--	.35	.39
45	--	.00	.01+	1.10	--	.38	.43
49	--	--	.01-	1.20	--	.42	--
50	--	--	.00	1.30	--	.45	--

Ground water storage values were derived from the depletion curves. Table 4 shows the smallest watershed with a storage capacity of 0.14 inches and the two larger watersheds showing a capacity of approximately 0.45 inches.

Table 5 lists the average midnight values of flow for the last day of each month, February showed the highest storage values, 0.10, 0.29 and 0.29 inches of storage, respectively, and July and September showed the lowest storage values of 0.00, 0.03 and 0.04 inches, respectively.

Table 5.--Average groundwater storage at midnight of last day of month (in inches).

Month	Green Acre Branch	Little Beaver Creek	Beaver Creek
June	.07	.15	.12
July	.00	.03	.04
Aug.	T	.09	.06
Sept.	0	.03	.04
Oct.	.07	.08	.10
Nov.	.02	.08	.08
Dec.	.06	.18	.16
Jan.	.03	.12	.12
Feb.	.10	.29	.29
Mar.	.06	.17	.19
Apr.	.02	.14	.18
May	.04	.17	.16

Athens Research Center

by W. H. Carmean

General

During the past six months compiling and analyzing of data has been continued.

Relation between soil topography and site quality of black oak in Southern Ohio

Thirteen site plots originally established by R. N. Gaiser in 1949 and 1950 were relocated and remeasured. Data from these plots were grouped with data collected in connection with current black oak soil site investigations. Measurements of 105 black oak site plots are now available for analysis. Preliminary plotting of independent variables has been completed, and a multiple regression analysis will be made within the next few months.

Effects from converting ridge sites from hardwood to pine on the Vinton Furnace Experimental Forest

Surface Water Runoff from Small Plots

Results of a preliminary analysis of data were described in the October 1956-March 31 semi-annual report. Regression analysis of data has been completed for runoff troughs located in the clearcut blocks. Results of this analysis are as follows:

Regression	Degrees of Freedom	Variables tested 2/								
		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
Clearcut plots -winter storms	129	**	**	**	-	-	-	-	-	-
clearcut plots -thunderstorms	99	-	-	**	-	-	-	*	-	-
clearcut plots -all storms (winter, thunder, intermediate storms 1/	277	**	-	-	-	-	-	-	-	-

** significant at the 1% level
* significant at the 5% level
- nonsignificant

1/ Winter storms have intensities less than 0.5 inch/hr. for 15 minutes, thunderstorms have intensities greater than 0.5 inch/hr. for 15 minutes, intermediate storms have varied intensities or may have brief interludes without rainfall.

2/ Y = quantity of runoff for individual storms
X_1 = precipitation in inches
$X_2 = 1/X_1$
X_3 = maximum precipitation intensity for 15 minute period
$X_4 = 1/X_3$
$X_5 = X_1 \times X_4$
X_6 = soil moisture content
X_7 = hours since last precipitation
X_8 = days since May 1
$X_9 = 1/X_8$

Regression analysis of runoff data from all treatments is continuing and will include calculation of regression coefficients and the significance of coefficients and equations.

Soil Moisture

Weekly soil moisture measurements were taken from April 1954 through December 1955 in an undisturbed oak forest on a "poor-site" ridge and on a "poor-site" clearcut and planted to pine.

Litter

Litter samples have been collected annually since clearcutting in 1953 and planting in the spring of 1954. There are changes in weights for the "L", "F", or "H" organic layers from the clearcut blocks with natural regrowth. How significant these changes may be from a protection watershed standpoint requires additional data and analysis.

Effect on Southern Ohio vegetal cover types on water available for streamflow

Weekly soil moisture measurements are currently being made on five areas of contrasting vegetal cover conditions. These conditions include: (1) undisturbed oak forest; (2) undisturbed shortleaf pine forest; (3) bromesedge grass on abandoned agricultural land; (4) sumac on abandoned agricultural land, and (5) a clearcut shortleaf pine area. Moisture measurements may be completed during the coming dormant season.

Berea Research Center

Berea College Forest

Negotiations are progressing very well for using the 6,000 acre Berea College forest for research and pilot plant demonstrations. An inventory of the forest was completed this spring. During May, Station personnel and Berea College technicians planned the location and layout of logging roads and major skid trails essential for removing products and placing the area under management. Over 55 miles of roads were planned and spot checked in the field. Specifications were assembled for preparing a detail logging plan of the forest.

Mine acid drainage

The effects of mining upon soil, streamflow, water quality and sedimentation indicate we have several difficult technical problems that should receive high priority in our research program. Starting to tackle this watershed problem we found limited information on number, location and types of mining activity discharging water. During July, this Center cooperated with the Cumberland National Forest to devise a procedure and standards of inventorying mine acid drainage and mining activity. The Berea Ranger District was selected as the sample unit and there were 67,500 acres surveyed by late summer. Tables 6, 7 and 8 summarize some of the data obtained during this survey on 67,500 acres of National Forest land.

Table 6.--Mine acid discharge, 1957 - Berea Ranger District

Kind of Mine	Discharge			
	Continuous	Intermittent	None	Total
Drift	16	15	5	36
Strip	2	7	2	11
Oil wells	-	13	-	13
All discharges	18	35	7	60

Table 7.--Soil erosion by type of mining activity, 1957 - Berea Ranger District

Kind of Mine	Erosion		
	Active	Negligible	Total
Drift	24	12	36
Strip	8	3	11
Oil wells	13	-	13
Total	45	15	60

Table 8.--Mining activity, 1957 - Berea Ranger District

Kind of Mine	Operation		
	Active	Inactive	Total
Drift	9	27	36
Strip	1	10	11
Oilwell	7	6	13
Total	17	43	60

Strip mine study on Cumberland National Forest

The third annual meeting of the working group committee was held in June. It was agreed by the group the study should be continued for another year, the reclamation treatment should comply with Kentucky laws, measurements should be as accurate as possible, and a preliminary progress report on this project be made by June 1958.

This fall a drift mining operation started on the stripped watershed. Arrangements are underway to have an in-Service meeting on the future of this Forest Service administrative study.

MEETINGS AND TALKS

July 25 — Carmean was program chairman at the annual meeting of the Ohio Chapter Society of American Foresters held at Lake Hope, Ohio. Carmean presented a 36-page mimeographed report of the Southern Ohio Cutting Practice Committee entitled "Recommended Management Practices for Forest Land in Southeastern Ohio." A field trip was conducted by Carmean to observe soil, topographic, and stand conditions of several contrasting soil-site plots established in the Lake Hope area.

July - August — L. Hill, as member of the research team at Coshocton, gave lectures or talks regarding forestry at stops on guided tours. Over 600 individuals at the Coshocton Hydrologic Laboratory heard Hill's comments regarding watershed management for forest areas.

PUBLICATIONS

Manuscripts Published

Carmean, W. H. 1957 — The Structure of Forest Soil. Ohio Jour. Sci. 57: 165-168.

Manuscripts Submitted

Carmean, W. H. 1957 — Silvical characteristics of yellow buckeye.

New Manuscripts

Carmean, S. H. — The role of environment and tree physiology in determining site quality for forest trees.

Stone, Earl L. Jr., and Carmean, W. H. — An evaluation of forest soil-site methods.

SEMIANNUAL REPORT ON WATERSHED MANAGEMENT RESEARCH
Intermountain Forest and Range Experiment Station
April - September 1957

GENERAL

Functional inspections of Watershed Management Research activities were conducted at the Great Basin and Boise Research Centers during the summer. Special emphasis was placed on the development of problem analyses and study plans.

Personnel

Otis L. Copeland Jr. joined the Station staff as Assistant to the Chief of the Division, and will also provide assistance to other divisional and field personnel on matters relating to the forest and range soils of the Station territory. Dr. Copeland was formerly Soil Scientist at the Inland Empire Research Center in Spokane.

Richard O. Meeuwig completed one year of advanced study at the University of California and returned to his duties with the Station. He was subsequently assigned to the Great Basin Research Center.

Richard B. Marston resumed his studies toward the Doctorate at the Utah State University in September.

BOISE RESEARCH CENTER

Logging Road Reseeding Study

In 1955, a study was begun to determine means of establishing plant cover that would control, effectively, erosion on logging roads. During July, field data on the establishment of perennial grass cover on two logging roads were gathered. Data taken this summer will be analyzed statistically to determine if significant differences occur between methods of roadbed treatment on the number of plants established, vigor, and dry weight of cover produced.

Another phase of the investigation into controlling erosion on logging roads and skidtrails was examined this summer. Skidtrail erosion control measures (log water bars, brush dams, shovel ditches, and lopped and scattered slash) on four national forest sale areas were evaluated qualitatively to determine their condition and effectiveness in controlling erosion. Other points noted during the course of this examination were: (1) the relative amount of natural revegetation on the skidtrails; (2) amount of reseeded vegetation; (3) relative amount of rilling and gullying; (4) whether the structures were retaining any sediment and whether sediment had over-topped or by-passed the ends of the structures; and (5) a general observation as to

whether the structures were spaced correctly for the degree of slope. An analysis of these observations, coupled with quantitative measurements obtained last year, is expected to provide a basis for recommendations as to the most efficient erosion control measure and its spacing on various slopes.

Cover Restoration on High Elevation Range

The range cover restoration study, established on the upper slopes of Morehead Mountain in 1956, was examined this summer. Sixteen new 50-foot line transects were established on the plots between contour trenches to obtain more complete data on amount of live vegetation and litter. The range in ground cover, this year, was from 25 to 44 percent, compared with the before treatment range of 18 to 42 percent. Several more years of remeasurements will be necessary to determine a definite trend in cover establishment.

Bannock Creek Sediment Production Study

Ten of the 20 sediment-trap dams installed in Bannock Creek to determine sediment production caused by logging were resurveyed this year. Only three dams showed a measurable increase in sediment catch over last year. The top producer, Compartment 4B, is contributing sediment at the rate of 92 lbs./A/yr., or 29.5 tons/sq.mi./yr., most of which is derived from a logging road near the stream bottom.

Hydrologic Study

Several small watersheds in the Crooked River drainage were examined during August. A number of comparable watersheds are desired for hydrologic studies under ponderosa pine management and logging practices. Other drainages are also being considered as locations for these studies.

NEVADA RESEARCH CENTER

Problem Analysis Started for the Truckee River Basin

In the past six months, some progress has been made in developing a detailed analysis of the watershed management problems of the Truckee River Basin. Most of the effort has gone into collecting reference material, making trips over the area, and discussing the problems with interested groups. This coming winter will be devoted to the formulation of a working plan for review next year.

Center Office Completed in Reno

In the latter part of September, work was completed on the new Center office-laboratory. The job was contracted locally and involved the remodeling of a residence building and garage moved from Paradise Valley, Nevada, to Reno.

Manuscripts Completed for Review or in the Preparation Stage

In between time spent on the problem analysis and looking after the contract job, Haupt has been preparing three papers that will report data obtained while he was stationed at the Boise Research Center:

1. "Soils Bared by Harvesting Ponderosa Pine." Describes extent to which soil is denuded by two cutting and logging systems being investigated on a long-term timber production study area in the Boise Basin Experimental Forest.

2. "Road and Slope Characteristics Affecting Sediment Movement from Logging Roads." The amount of erosion and sediment occurring below logging roads at 75 locations in the ponderosa pine type is related to seven road and slope variables.

3. "A Logging Road Location Guide for Better Watershed Management." Describes in detail how an estimating equation mentioned in the above report may be used as a guide for determining the safe width of buffer strip to have below a logging road in order to protect lower roads traversing the same slope or a stream channel from erosion damage.

GREAT BASIN RESEARCH CENTER

Sediment Production

This is the first year of sediment measurement from the Left Fork and Alpine Cattle Pasture Watersheds. Spring sediment production from the Left Fork averaged 3.52 cu. ft/A. and from the Cattle Pasture, 5.15 cu. ft/A. The value for the Left Fork probably is low because the sediment basin is small and a portion of the clay fraction may have been lost. Progress is being made towards calibrating the streamgaging installations on these two watersheds. A 90° V-notch weir was installed between the sediment basin and the stilling pond at the Alpine Cattle Pasture streamgaging station, in order to rate the 120° V-notch weir. Heads were measured periodically on the 90° and the 120° V-notch weirs, and a good linear relationship was obtained between the heads throughout the range of flows measured. Head measurements of the 120° V-notch weir varied from 0.04 to 0.33 feet. In this range the head of the 90° V-notch weir was 1.31 times the head of the 120° V-notch. Using this value and the 90° V-notch discharge equation, a discharge equation for the 120° V-notch was calculated as: $Q = 4.90\ H^{2.47}$.

This equation agreed very well with current meter measurements taken this spring at heads of 0.915 and 1.06 feet, and so may be considered valid for heads of about 1 foot. Next spring, current meter measurements will be taken at greater heads to test further the derived equation.

Area A of the long-established A-B Watersheds produced sediment at the rate of 5.16 cu. ft./A., while Area B, which was plowed and re-seeded five years ago and protected from grazing, produced only 0.11 cu. ft./A. No sediment was produced by summer storms on either A or B areas this year.

Since about 1920, Area A has been allowed to revegetate naturally, with little or no grazing. Area B was subjected to moderate grazing for a number of years prior to World War II. After the war, this area was grazed heavily and became severely depleted. In 1952, intensive treatment was applied to restore the cover on this watershed. Ground cover densities were estimated this summer by the square-foot method. Area A shows little change in ground cover density from earlier measurements of 20 years ago, although there have been changes in ground cover composition and the watershed continues to produce sizeable amounts of sediment. Area B shows a highly significant improvement in grass cover and a major reduction in broad-leaved forbs, with an accompanying major decrease in sediment production. Ground cover on Area B is more uniformly distributed than it is on A. Area B cover is now comparable to what it was previous to the destructive grazing imposed during the late 1940's.

Publications

Intermountain Forest and Range Experiment Station, Research Paper No. 47, entitled "Effects of Plowing and Seeding on Some Forage Production and Hydrologic Characteristics of a Subalpine Range in central Utah", by Howard K. Orr, was released in June. Results of this study show that reseeding and protection from grazing for 3 years brought about a substantial improvement in forage production, but no significant change in surface runoff control, infiltration, and erosion control. Further thickening of vegetation and litter and improvement in control of runoff and erosion is expected on the treated areas in the years ahead.

WASATCH RESEARCH CENTER

Vegetation Water Use Study

A new study was initiated late in the summer to determine some of the water-use characteristics of aspen and mountain-brush vegetation. Twenty-four plots, 12 in each vegetation type, have been selected. Points at which ground cover will be estimated have been located, and a trough-type interception gage installed on each plot.

Observations now being made in each plot include gross precipitation, temperature, wind velocity, and evaporation. Other work going forward includes the digging of soil pits, collecting soil samples, and installing access pipes for the new neutron scattering soil moisture meter.

For the soil moisture measurements, a meter that employs the neutron scattering principle, was purchased from the Nuclear-Chicago Corporation. This soil moisture meter is a refinement of the model used by Kirkham and associates, Iowa State College.

Access pipe used in the calibration of our meter was cold-drawn, seamless, steel tubing, 20 gage, o.d. 1 5/8-inches, i.d. 1.555-inches, with a wall thickness of .035-inch. The access pipe to be used in this study is electrical, metallic, thinwall tubing, o.d. 1.74-inches, i.d. 1.61-inches, zinc-coated, seamless steel.

Ken Reinhart, during his recent visit to the Davis County Experimental Watershed, observed the instrument we have obtained and offered comments and suggestions that will be of value in the operation of this meter. Reinhart recently has been using an instrument similar in principle, but different in design. It would be interesting and informative to be able to compare the functioning of these two meters under identical conditions.

Free Water Surface Evaporation Study

Evaporation from a free-water surface is being measured from three different sizes of pans: (1) 48 inches inside diameter, 15 inches in depth; (2) 47.5 inches inside diameter, 10 inches in depth; and (3) 6.5 inches inside diameter, 8.5 inches in depth. The largest pans, in use at this Station for other studies, are being maintained for use in calibrating the 47.5 inch by 10-inch pans, now the standard size used by the U. S. Weather Bureau. The small pans, easily obtained, installed, and maintained, are being calibrated against both larger-sized pans.

Information on evaporation losses from 2 sizes of pans (48 inches in diameter x 15 inches depth and 8 inches diameter x 10 inches depth) at 2 sites was obtained this year. One site is on a west-facing slope in an aspen forest opening near the head of Parrish Creek at an elevation of 8,280 feet; the other is on a north facing slope in an aspen forest opening in the Chicken Creek area at an elevation of 7,650 feet.

Evaporation from the 8-inch diameter pans exceeded that from the 48-inch diameter pans by 27 percent at Parrish Creek and 18 percent at Chicken Creek.

Evaporation data for this test are summarized below:

Location	Water Evaporated From		Difference	Increase
	8-inch pan	48-inch pan		
	(inches)	(inches)	(inches)	(percent)
Parrish Cr.	28.07	22.17	5.90	27
Chicken Cr.	22.70	19.30	3.40	18

Evaporation from the large pan at Parrish Creek was 11 percent greater than at Chicken Creek during the period June 13 - Oct. 19, 1956 (Semiannual Report Oct. 1956 - Mar. 1957.)

New Streamgaging Station

A new streamgaging station was constructed in the mouth of Parrish Creek during July. It has a 120° V-notch weir and a stilling pond measuring 30 feet by 25 feet. A 3-foot high trash screen, extending the full width of the pond, is located on the upper sill which is at the same elevation as the bottom of the V-notch. A by-pass extends along one side of the structure to facilitate cleaning the main weir pond and small sediment pond in front of the upper sill.

This structure was rather expensive because of difficulties encountered in tying into stable streambank material. It's construction was necessary because of new diversions that were installed above the old gaging station. Sediment measurements can now be made at the new station. They are particularly desirable because of the importance of this drainage in the Davis County Experimental Watershed.

MISSOULA RESEARCH CENTER

Regional Watershed Management Research Problems

A brief summary of the watershed management research problem analysis developed for the Region 1 portion of the Station territory was presented earlier this year in the Station's Annual Report. This analysis pointed out many watershed management problems and indicated the kinds of answers needed for their solution. Of these many problems, three are believed to be of greatest importance and most in need of investigation. One is how to prevent damaging increases in snowmelt runoff peaks and sediment production from forest lands of the upper Columbia River Basin under the impact of timber harvest and roadbuilding activities. Another, is how to increase summer streamflow, without creating damaging increases in summer storm or snowmelt runoff peaks and sediment by managing forest cover in the upper Missouri River Basin. A third, is concerned with how to restore control of damaging storm runoff and sediment production from deteriorated range lands in the upper Missouri River Basin.

Prevention of Watershed Damage

The white pine forest type is considered to be the priority problem area of the Region where management methods for preventing watershed damage are needed. Development of methods to cope with this situation requires learning how to cut the timber from a watershed so that the rising stage of the streamflow hydrograph begins earlier and the depletion stage continues longer, thereby broadening the base of the hydrograph without increasing its peak discharge height. The other

line requiring investigation is how to reduce or prevent overland flow of water on disturbed areas, such as roads and skidtrails, becoming of sufficient magnitude to erode soil and deposit sediment in stream channels.

With the facilities available, the following program of research in white pine forests has been started:

1. Complete analysis of large amounts of snow behavior data collected between 1949 and 1952 at the Priest River Experimental Forest.

2. Locate and reserve from timber cutting at least 6 experimental plot areas of thrifty, mature white pine.

3. Design and develop detailed plans for studies of various hydrologic processes on these areas.

4. Design and develop detailed plans for studies of various hydrologic processes on roadbeds, cuts, fills, and on skidtrails in comparable white pine sites.

5. Locate and reserve from timber cutting at least 8 experimental watersheds.

Improvement of Water Yields

The problem of how to manage the forests of the Upper Missouri Basin to improve summer water yields is another problem of primary concern in the Northern region. These forests, principally of lodgepole pine and spruce-fir, receive a moderately heavy snowpack in most years. Snowmelt occurs during the spring, releasing about 75 percent of the annual streamflow by mid-July. As a result, local deficiencies occur almost every year after mid-summer. Proposed activities during the next several years include:

1. Locating and reserving from timber cutting at least 6 experimental plot study areas.

2. Locating and reserving from timber cutting at least 8 experimental watersheds having essentially similar topographic, forest cover, and soil characteristics.

Restoration of Protective Watershed Conditions

How to restore plant cover and soil conditions capable of controlling summer storm runoff and soil erosion on deteriorated rangelands of the Upper Missouri Basin is a third watershed management research problem of prime importance in this Region. Many kinds of studies, including basic hydrologic studies of precipitation, infiltration, overland flow, soil detachment, sediment transport and deposition, and soil moisture storage, as well as studies of the effects of different plant cover, soil, grazing, and structural treatments on these processes will be required.

Measures for Controlling Surface Runoff and Erosion on Logging Roads

The following activities in connection with this problem are proposed for the next few years:

1. In cooperation with the Region, develop a comprehensive outline for an illustrated handbook of watershed protection guides.

2. Fill in portions of this handbook by adopting tentative prescriptions or measures on the basis of information now available.

3. Cooperate with the Region in developing a plan for obtaining additional information needed to develop other guides or improve existing ones.

4. Continue to render assistance to Region in evaluating additional information and formulation of tentative guides for testing on subsequent logging areas.

Meetings

During this past spring and summer, Packer presented the keynote paper at the annual meeting of the Montana Conservation Council in May. He also presented papers to the Regional Advisory Committee and the Montana League of Women Voters this spring. More recently, he presented a paper at the annual meeting of the American Fisheries Society in Las Vegas, Nevada. These papers were designed to acquaint people with the hydrologic importance of different kinds of watershed problems, with those problems of prime concern in different areas of the west, particularly in Region 1, and with the kinds of research and amount of research effort needed for their solution.

Training

In August, Packer attended the two-week training conference on Snow Hydrology conducted at Portland, Oregon by personnel of the recently deactivated Snow Investigations Unit of the Corps of Engineers.

Publications

Released under date of June 1957 is Station Miscellaneous Publication No. 14, "Intermountain Infiltrometer" written by Packer. This paper is a photo-illustrated handbook that presents the installation, calibration, operation, and construction specifications for an improved infiltrometer designed at Intermountain and used in a number of studies during the past several years.

"Possibilities for Improvement of Water Yields from Mountain Watersheds in Sevier River Basin." This paper, presented by Packer to the Sevier River Basin Study Committee, was released as a part of that Committee's report.

"Watershed Management Problems and Research Needs in the Northern Region," presented by Packer at the Montana Conservation Council annual meeting, has been mimeographed and distributed by Region 1 and the Council. Revision of this paper is being made for publication in the near future as a Station release.

LAKE STATES FOREST EXPERIMENT STATION

WATERSHED MANAGEMENT RESEARCH SEMI-ANNUAL PROGRESS REPORT
April 1 to October 1, 1957

GENERAL

This is the first report of the reactivated Watershed Management Division. The year was spent in recruiting personnel, getting acquainted with the area and its people, and initiating a limited program of research at several Centers.

There was a watershed management research program under way at the Lake States Station in the early thirties. Most of the early effort was in the 10,000-square-mile unglaciated section of southwestern Wisconsin and southeastern Minnesota. With the advent of World War II all watershed management research activities stopped at this Station.

Here are some names and some places that you will be reading about in the future:

1. Sid Weitzman is Division Chief at St. Paul, Minnesota.

2. Roger Bay is the watershed man in charge at Headwaters Research Center at Grand Rapids, Minnesota.

3. Dave Striffler is on the job at Lower Peninsula Research Center at East Lansing, Michigan.

4. Joe Stoeckeler has been spearheading work in the Driftless Area.

PROGRAM

A description of the watershed problem areas was given in the Station's 1956 annual report. This background material may be useful in understanding the nature of the problems and the purpose of the program.

Headwaters Research Center

This problem area lies in the northern forest region. It occupies the 20 northern-most counties of Minnesota. This is a glacial area. It is also an area of lakes and swamps with level to gently rolling topography. Indiscriminate cutting, followed by fire, brought about a conversion of forest cover--largely from pines to aspen. (For more details about the area see the 1956 annual report.)

The emphasis of the research effort at this Center is twofold: (1) Collect some background material as a basis for guiding future research, and (2) determine the effect of the wholesale conversion of forest types following the clear cutting followed by repeated fires.

To this end, studies were started to determine the effect of the different cover types on the various phases of the hydrologic cycle. Tentative results follow.

Snow and frost

Snow and frost observations were collected in a number of different forest types in northern Minnesota during winter of 1956-57. Computations were recently completed. During the spring unusually warm temperatures combined with a heavy rain resulted in a complete melt of snow in a period of 1 week. Prior to this, the rate of accumulation and subsequent melt occurred in a logical pattern for this area.

More snow accumulated in the open and aspen stands than in the pine stands at Cutfoot Sioux Experimental Forest during buildup. Snow disappeared first in the open, then in the aspen, red pine with 60 square feet of basal area, red pine with 100 square feet of basal area, and finally in the densest red pine (140 square feet of basal area).

Different stocking densities of aspen on the Pike Bay Experimental Forest were studied. Snow depth and water equivalent differences were slight. Compared to nearby conifer stands of balsam fir, white pine, and jack pine, there was a higher water content in the conifers prior to spring melt. On April 17, just prior to total melt, average snow depths in the open, aspen, and combined conifers were 0, 7.9, and 12.0 inches; while average water contents were 0, 2.6, and 3.5 inches respectively.

Snow accumulation and melt under various cutting methods of black spruce in a level spruce bog were also studied. Melt was most rapid in a large clear-cut patch, followed by a shelterwood area, an uncut check unit, and a tree selection method. Just before complete melt, most snow was found in an east-west, clear-cut strip. During the period of accumulation the narrow (66 feet wide) strip accumulated snow quite like the open area, but during the melt period snow melted much more slowly due to effective screening of the sun's rays.

Observations on the type and occurrence of frost were made in conjunction with the snow measurements and in the same cover complexes. In general, it was found that the occurrence of concrete frost in a spruce bog (organic soils) followed a pattern much like frost occurrence in mineral soils. The average depth of concrete frost in a clear-cut patch was 2.6 inches and percent of occurrence was 77 percent, while in the fully stocked check unit average depth was only 0.4 inch and percent of occurrence was 17 percent.

Soil moisture

Throughout the summer soil moisture samples have been collected under the same cover complexes in which snow was studied. These will be used to evaluate overwinter recharge of soil moisture and to obtain some idea of the moisture relationships in these various types. Much of this work was handled by summer student Albert Clegg.

Project analysis

A rough draft of a project analysis for the Headwaters area is under way to help point the direction of future studies in watershed management research.

--- Roger Bay

Driftless Area Research

The area

The Driftless Area of southwestern Wisconsin and southeastern Minnesota (it also has some area in northeastern Iowa and northwestern Illinois) contains about 10,000 square miles of land. The soils are mostly rather erodible silt loams of loessal origin, and are usually 2 to 8 feet deep over limestone or sandstone. The rolling hills are 300 to 600 feet above the level of the Mississippi River and its tributaries.

Forest cover generally occupies about one-third of the area of any one tributary. The remainder is in corn, alfalfa, small grains, and pasture. The area classifies as "America's dairyland."

The typical landscape consists of ridgetop farms, narrow bands of timber on slopes of 25 to 50 percent, and intensively farmed valley bottomlands and terraces. The upland farms have considerable runoff which is channeled and dumped into the woods forming gullies on slopes and in the valleys. Ownership by one individual of land on the ridges as well as in the valleys complicates the problem because rut roads and cattle trains running from ridge to valley on such "two-storied" farms often grow into gullies.

About 80 percent of the farm woods are grazed. The compaction results in accelerated runoff, especially in high-intensity storms. Grazing of the woods is a major problem. (For other details see 1956 annual report.)

Current activities

In recognition of the severe flood and erosion problems in the area, the Station started its original watershed research program in this area in the 1930's. There are plans to reactivate some watershed research work in the area. The initial effort has been spent in scouting for suitable experimental forest areas.

Also under way during the summer was a preliminary reconnaissance study of soil moisture behavior in several important land-use conditions in the area.

--- J. H. Stoeckeler

Lower Peninsula Research Center

A cooperative watershed agreement with the Michigan Conservation Department provided the basis for starting a program of research in the area.

The area of Lower Michigan Research Center covers that portion of Michigan south of the Straits of Mackinac, usually referred to as Lower Michigan or Lower Peninsula. This glaciated territory may be divided into two portions. The northern portion is heavily forested (60 to 90 percent), underlain by sandy soils, lightly populated, and relatively new geologically. The southern portion is covered by woodlots (25 percent), has heavier textured soils, is the agricultural area, also a densely populated industrial area. Conflicting interests and demands by industrial, recreational, domestic, and agricultural (irrigation) requirements are creating local water shortages.

Activities

A full-time research forester is now on the job. He is selecting study areas and getting acquainted with the area and its problems.

Professor Dils of the University of Michigan spent the summer collecting data for project analysis.

Infiltration in Frozen Ground

In March and April of 1957, over 200 infiltration runs were made with single-ring steel cylinders of 4-inch diameter. These runs were made on the Chippewa National Forest in northern Minnesota to (1) evaluate and refine techniques, and (2) to determine relative infiltration in different types of frozen soil. A preliminary evaluation of the data reveals the following:

1. Concrete type of frost described by Post and Dreibelbis is virtually impenetrable to water for 10-minute periods, transmitting less than 0.1 inch. Even on a full hour run, with a substantial head of water of about 3 inches, it took very little water.

2. A frost type, not mentioned to date in the literature, was observed. Sandy soils frozen at low moisture content have high resistance to the steel probe frost penetrometer. Yet these soils will transmit moisture at a substantial rate as follows: For the first 10 minutes, 31 runs averaged .85 inch and on a per-hour rate, 21 runs averaged 1.46 inches. One can readily blow air through porous hard frozen dry sandy soils. Should we call this a "dry concrete frost type"? We would welcome some suggestions on nomenclature!

Publications

Several popular articles were published:

Weitzman, Sidney. Needed--A Forest Research Program for Southwest Wisconsin. Wis. Conserv. Bul. 22(3): 28-33, illus. March 1957.

Weitzman, Sidney. Problems of Watershed Management. The Conserv. Volunteer 20(115): 8-13, illus. January-February 1957.

Weitzman, Sidney. There's Water in the Forests. The Conserv. Volunteer 20(116): 18-22, illus. March-April 1957.

Also problem analysis for Station territory:

Dils, Robert E. Watershed Management Research Needs in the Forests of the Lake States. Special Bulletin 416. Mich. State Univ. Agric. Expt. Sta., May 1957.

Visitors

Dave Striffler, in charge of our watershed management research program at the Lower Michigan Center, spent several days in July getting acquainted with the work at Headwaters Research Center. He liked everything but the mosquitoes, black flies, and Roger Bay's fishing stories.

Herb Storey toured the area during September. Herb climbed gullies in southern Wisconsin, flew over part of the famous Minnesota canoe country on the Superior National Forest, visited site studies in the middle of a black spruce bog, dug into our famous Billy-goat and Marianne soils in Michigan, and looked over study areas. He particularly enjoyed listening to Indian stories from Zasada.

Dr. Harper spent a day driving through the Driftless Area enroute to Madison, Wisconsin, and the AFA meeting.

Marvin Hoover stopped in after his meeting at St. Anthony Park Hydraulic Laboratory. Enjoyed exchanging ideas on program. We need more of this.

NORTHEASTERN FOREST EXPERIMENT STATION

Division of Watershed Management Research

Semi-annual Report October 1957

GENERAL

The past 6 months have been marked by personnel changes, additional cooperative studies, and initiation of treatment at the Fernow watersheds. Calling the roll by Centers, our situation is about as follows:

Mountain State. Dick Trimble stepped into Sid Weitzman's shoes in July as Center Leader: they appear to fit. Treatment started in May on the 6-year calibrated watersheds. Cooperative watershed research with the Union Carbide Chemicals Company was made possible in a memorandum of understanding.

Kingston. The first weir was poured in our cooperative study with Penn State and the Department of Forests and Waters.

White Pine-Hardwood. Dick Sartz took over the Hubbard Brook project vice Trimble and Ray Leonard was added to staff. Also added: another weir and 2 miles of road.

Coastal-Oak Pine. Si Little et al prepared a paper describing the effect of waste water recharge on vegetation and soils, and possibilities of a study at the Bridgeport red-pine watersheds were considered.

Virginia-Pine Hardwood. Al Snow's Center developed a memorandum of understanding to conduct watershed research on the reservoir properties of Baltimore, Maryland.

We (editorially speaking) rarely comment on what we read in the semi-annual report (this is my first letter to your magazine) mostly because comments are hard to keep fresh for 6 months and are better handled by mail. But we would like to applaud Hoover's eloquent plea, in the last report, for a thoughtful, basic approach to watershed research. Here in the watery East (with less water available per capita than the arid West) we are not overly impressed by the argument that it takes 1,000 gallons of water to make a Coca Cola--therefore more watershed management research is necessary, nor does it occur to us that all our effort should go into the "how to" research even though efforts in other directions resist classification under the uniform project system. Water isn't our limiting resource, it's curious researchers.

Speaking of curious researchers, one of ours, Dick Sartz, hopes to make a trip West next spring to see what's going on, and pass on the secrets of Hubbard Brook.

KINGSTON RESEARCH CENTER

It was a great summer for foresters and resort owners in the Poconos. No rain, no insects interfered with the delights of field work, swimming, boating, and lolling.

Of course, it was pretty dry; some perennial streams and springs stopped flowing and at least one heavily-used recreational lake did not have much water in it. The Pocono Experimental Forest had the lowest monthly rainfall, slightly less than an inch in August. Dilldown had the lowest two-month total, 2.70 inches for July and August. Even so, it was oasitic in comparison to the desert-dry conditions south and east of the Poconos.

WATERSHED MANAGEMENT

Leading Ridge Watershed

With an absolute minimum of difficulty, the watershed study on Leading Ridge Watershed No. 1 is under way at State College, Pa. The fine all weather road allowed ready-mix concrete trucks to back right up to the weir site and chute their high-quality concrete right into the forms.

The apron was poured on July 16, the superstructure on July 26. On August 27, the wing walls were poured and the gage-house completed. The instruments were installed in the gage-house and weather station on September 19, and records began from that date.

Although the difficulties were at a minimum, there was a great amount of planning and perspiration involved. The Pennsylvania Department of Forests and Waters had all the materials delivered at the correct times. Mr. J. J. Malloy, of the U. S. Geological Survey and the Department of Forests and Waters in Harrisburg rendered invaluable advice on the design of the weir. The Penn State staff, Dick Byrnes, Dave Worley (now with the Forest Service in Beria, Kentucky) and the student assistants did most of the work at the site, and in an excellent manner. Ken Reinhart from the Mountain State Center helped with the planning and the superstructure pour. He was the only one on the job with previous weir construction experience; his advice and skill was most helpful. Gene McNamara, Art Eschner, and Irv Reigner assisted in the planning and construction, and gained valuable experience in weir-construction.

Although we do not have rainfall data for the summer months in the Leading Ridge area, it was dry. But the stream maintained a steady flow. We feel pretty certain that zero flow will never be experienced.

Watershed Calibration

Although interrupted much of the time by other activities, we were able to spend a fair amount of time on the calibration analysis.

A recent test of our ability to predict annual runoff turned out amazingly well. All estimates were within a few tenths of an inch of annual runoff--percentagewise almost infinitesimal.

Using runoff years beginning and ending with those months in which there was no snow storage, we found no difference between years beginning with various months. Surprisingly, our largest error was found in the yearly analysis beginning October 1. One year's estimate was 36.30 inches against 35.90 inches actual runoff. This was the largest error in any of the analyses.

The parameters used are:

1. Annual precipitation

2. Sum of temperatures over 30°F. Here we merely summed all maximum and minimum temperatures above 30°. Those temperatures below 31° were ignored.

3. Estimated storage change. Using our best equation to estimate storage, we estimated the storage at the beginning and end of each year. The difference, of course, is estimated storage change.

Using five years of record in each case, we analyzed those years beginning in May, June, July, August, September, and October.

One refinement in the prediction of monthly streamflow that removed a considerable amount of the previously unexplained variation is the use of a curved "correction" for large storms. One large storm contributes much more to current streamflow than several smaller storms of the same total rainfall. The smaller storms contribute more to storage gain.

As we have been using P-RO (which is storage gain plus evapotranspiration) as our dependent variable, we found that the 3/4 power of daily rainfall improved the relationship. A disadvantage of using an exponential form of daily rainfall is that it heavily weights all storms under one inch. Thus, a synthetic curve was devised using an arc of the circle beginning at zero.

For most of the range of the data, this is an unnecessary refinement. But in those months that have large daily rainfall figures, say four inches and above, the "corrected" figures are quite an improvement.

Another refinement is the grouping of months into categories of similar beginning storage, after it was found that the parameters differ depending on beginning storage. The categories are determined with a general equation estimating beginning storage. For example, in those months with very low storage, unweighted monthly rainfall is used with unweighted 100 day antecedent rainfall. But in the next group, low storage, a weighted expression of "corrected" daily rainfall is used for the monthly precipitation figure and for the antecedent precipitation figure. These two groups cover the months, July through November; the correlations are extremely high.

This, I hope will be our final progress report on single-watershed calibration. By Christmas we should have the results written up (a Christmas present for Upper Darby) and headed for publication.

Soil Moisture

Taking advantage of several root-raked patches on the Dilldown watershed Eschner has set up a soil moisture study under a number of vegetative cover conditions. These include bare root-raked soil, an area where the vegetation has been deadened but left intact, an area with ericaceous ground cover, one with a scrub oak cover, and one with a combination of scrub oak and ground cover. Several side problems have come up in connection with this study which have relieved the routine of soil moisture sampling. Bulk densities have been determined for the plots and estimates of the rock content of the soil are being obtained. In addition, a small study on the wilting point of the fibrous mor humus is underway.

Accumulating data show some obvious differences that appear to be reasonable and fairly consistent. Soil moisture under the deadened vegetation has remained the highest in all cases; that under a complete cover of scrub oak and ericaceous ground cover the lowest. Under a cover composed mostly of sheep laurel the soil moisture has been depleted almost to the point reached under the combined ground cover and scrub oak. In the scalped plots soil moisture has been moderately low and more variable owing probably to the rough surfaces and considerably lower infiltration rate.

Rock contents of the various plots were determined by digging regularly shaped pits, sieving out the rocks, weighing them and computing their volume using their specific gravity. The volume of the hole was estimated by packing it with a measured amount of sawdust.

Interception

This May a new phase of a continuing study on rainfall interception losses from scrub oak and northern hardwoods was begun at the Dilldown and Pocono forests. This study was designed to show whether there is any loss due to throughfall splashing out of the eaves trough previously used to collect rain in studies of this sort.

Miscellaneous

Eschner returned unscathed from the Northeastern Forest Soils Meeting in August in New Brunswick, Canada. This is no mean feat, considering the number of S.C.S. men present with their wicked looking knives.

Three Lull boys, Howard, David, and Miles, spent a week on the scenic Delaware-Lehigh Experimental Forest late in July. There they took soil moisture samples, measured humus depths and picked blueberries.

MOUNTAIN STATE RESEARCH CENTER

After no more backing and filling than might be expected, the decision was made to terminate the calibration period and start cutting in the gaged watersheds after six years of measurement. On May 13 (we're not superstitious) Carl Barr moved the bulldozer over the white-painted boundary line of Watershed No. 1 and the clearcutting practice on that watershed was underway. Results already are coming in: Water turbidity during first storm measured was 1800 ppm on clearcut; 12 ppm on control.

We are continuing our search for methods to clean up turbid streamflow. Reinhart visited the Engineer Research and Development Lab at Ft. Belvoir in May but found that their equipment, devised for other needs, is not adaptable for our purpose.

Gaging started on our two operated watersheds in time to welcome the New (hydrologic) Year. This makes nine watersheds we are gaging.

Soil Moisture Studies

Last year was a very wet year on the Fernow. There was relatively little change in soil moisture contents between the wettest and driest dates samples. This year is much drier and some of the moisture contents obtained probably approach the wilting point. Thus our sampling efforts are being better rewarded. So far, just one soil-moisture plot in the watershed being clearcut has been cut over. Initial inspection of the data shows that there is a decided difference between moisture contents of this plot and uncut plots.

We have made some preliminary analysis to determine soil moisture differences between opposing aspects and different positions on slopes. While the results are tentative, it appears that southwest aspects and upper slope positions are definitely drier than northeast aspects and lower slope positions.

Our experience this summer with gravimetric soil sampling has been disheartening because the only King tube points we could purchase recently have not stood up through more than a day of sampling. We sent

out a call for help to a number of Forest Service watershed workers and received many good suggestions from Marvin Hoover, Lou Metz, Ed Dortignac and Hubert Burke. We trust that we will be able to purchase satisfactory points from R. C. Jordan of Riverside, California. If their points are unsatisfactory, we will try some of the other suggestions offered.

Neutron Moisture Meter

Some progress has been made with the neutron moisture meter. Changes made in the meter to overcome earlier troubles resulted in voiding of the calibration curve supplied with the instrument. A new calibration curve has been prepared by relating meter readings to moisture content values determined from core samples in the relatively stone-free soils of the nursery bottom adjacent to the Fernow Forest office. Initial efforts made to install access tubes adjacent to the soil-moisture sampling plots in the gaged watersheds have been encouraging. We used van Bavel's method of pushing in the access tube a short distance, removing the soil from within the tube by use of an auger just slightly smaller in diameter than the tube itself. The King tube was also used inside the access tube to loosen the soil.

Reinhart visited Dick Marston at the Farmington Research Center in Utah just after this Center received a nuclear moisture meter manufactured by the Nuclear Instrument and Chemical Corporation of Chicago. This model, having built-in battery and trickle charger, appears in some respects to be easier and more convenient to use than the W. B. Johnson Associates' model. It also has a scaler or counter rather than a rate meter. It will be interesting to compare at a later date the performance of these two instruments.

Truck Road Seeding

A few years ago several miles of experimental logging truck roads were built on the Fernow to log four of our timber management compartments. Several stretches of steep grade were incorporated in these roads to demonstrate problems encountered in using steep grade roads. The areas have been logged and the steeper grades (15-20%), even though well drained, began to erode very heavily this spring--thus fulfilling our expectations and making an excellent demonstration for logging operators of what they might expect of such roads.

To save our initial investment in these roads, which are needed for future logging operations and access to the area, we put in a number of new surface drains on the steep sections and then limed, fertilized and seeded them. The following seeding mixtures were used:

1. Chaff--40 bu./acre

or

2. Timothy - 10 lbs/acre
Red top - 10 lbs/acre
Ky. 31 fescue - 5 lbs/acre
Domestic ryegrass - 10 lbs/acre

Total 35 lbs/acre

The roads were limed at the rate of a ton of lime per acre and 500 pounds of 10-10-10 fertilizer. In spite of the fact that they were not seeded until about August 5--which was in an extremely dry period--the seeding came through in great style and we are assured that our roads are "saved". For about $200 we saved probably $2,000 in road investment money. This demonstration of what happens to steep grades and how to prevent disastrous washing on logging roads is selling a lot of good logging road practices in this area.

Cooperative research

High-light of a recent Advisory Committee meeting was an announcement that the Union Carbide Chemicals Company and the Mountain State Research Center have entered into an agreement to do research in southern West Virginia. This work will be centered at a new 2,500 acre experimental forest established on Company land near Charleston, West Virginia. Plans are now underway by both organizations for initiation of early studies on this area. Work on the new experimental forest will serve two special purposes. One--do research under the conditions found in southern West Virginia of which the Fernow is not strictly typical; and two--provide a center of research and demonstration for the numerous foresters employed in the southern West Virginia area. At present their location at a considerable distance from the Fernow handicaps them in following closely the results of Fernow research. Studies will be made on this area in the fields of timber management and watershed management, and both will be tied into wildlife management.

Streamflow computations

After studying ARS instructions, running sample computations, and considerable discussion, Ken Reinhart has come up with four changes in our methods of computing streamflow. We would like your comments on these.

1. Mark times and gage-heights on charts.

This information is then written down twice, on chart and on Form 6. However, this disadvantage is offset by the advantages. Reading of charts and checking the operation will be facilitated because all the work is on one piece of paper. Once the times and stage heights are written on the chart, the remaining job is a clerical one. As soon as the charts are marked and tabulated, they can be booked using Acco fasteners and simple manila covers. This will avoid confusing shuffling and sorting of charts.

2. For each weir, prepare new table of rating factors based on (a) present discharge table, (b) conversion from minutes to seconds, and (c) conversion factor accounting for area of watershed.

This factor would be entered on Form 6 in column for discharge rate. Multiplication of the factor by number of minutes in the time interval and dividing by 1,000 gives c.s.m. for the day. Area runoff (accumulated) in cu. ft. would be omitted. For maximum peaks, factor is multiplied by 1.44.

Values for each stage height are determined as follows: c.f.s. from discharge table X 60 X area factor for watershed. Setting this constant in the calculator, the table can be built up rapidly by multiplying by the values in the discharge table.

It will, of course, take some time to prepare the tables. However, the more simplified computation involved and the elimination of recording the accumulated cubic feet for the day (which has not yet been used for any specific purpose) should make such tables worthwhile.

3. In entering c.s.m. for the day and for maximum peaks, carry to 3 decimal places instead of 4 places as is now being done.

In testing this, the six month total discharge in area inches of water by the original method was 17.9253; by the "rounding" method, it was 17.926 or 17.9257. In analysis so far, annual totals of area inches have been used to 2 decimal places only. Thus it seems clear that 3 decimal places are sufficient when entering c.s.m. for the day on Forms 6 and 7. This should make computation and checking of Forms 6, copying to Form 7, and computation on Form 7 a much easier job than heretofore.

4. In figuring maximum peaks only peaks with stage heights of 0.3 ft. and above be considered.

Currently, maximum peak values are being computed even for very small peaks resulting from small storms. In peak flow calibration analysis, the only peaks that have been considered are those of 10 c.s.m. and over (based on flow on the control watershed). Perhaps in future analyses, smaller peaks will be included but very small peaks probably never will be considered. A value of 5 c.s.m. seems a logical lower limit.

In setting a dividing line for computation of peaks, a rule based on stage height is the most logical. It will also be simpler if the same rule can be applied to all watersheds. A peak of 5 c.s.m. at Watershed 2 (the smallest of the 5 watersheds) corresponds to a gage height of 0.333 feet. Stage heights for a peak of 5 c.s.m. at the larger watersheds are of course higher than at Watershed 2. For simplicity, it is recommended that peaks be tabulated and computed only when stage height is 0.300 feet or above.

Miscellaneous

Dick Trimble was transferred to Elkins as Research Center Leader effective July 1. Watershed soils man John J. Philips left for 6 months active military duty; his position is being capably filled by George Hart.

WHITE PINE-HARDWOOD RESEARCH CENTER

Our third, biggest, and most expensive weir to date is now in final stages of construction. It has a 120°, 2-foot V-notch with 4½-foot horizontal sections on either side; that is, a 2 foot V plus a 1½ by 16 foot horizontal section above the notch.

Like our other two weirs, this one has side walls. They extend at right angles to the cutoff wall for about 30 feet, then angle off into the bank. Depth of the pool at the notch with zero flow will be about 4½ feet.

The excavation proved to be a larger part of the job than we anticipated. After bulldozer excavation last summer it looked like a few days of hand work would expose solid ledge in the whole basin and that would be that. Not so. The ledge was not only very irregular, but it consisted of loose layer upon layer, with water and mud oozing out between the layers. Not knowing whether the loose layers were concealing water-porous seams or not, we had to keep peeling them off--ton after ton--by means of crow-bar, strong back, and the winch on our new Power Wagon. But now we have what we feel confident is a water-tight basin--solid ledge with all walls keyed into it.

The watershed above it is 95 acres--3 times the size of our other two.

For intake pipes on this weir we used 3-inch solid Orangeburg pipe instead of galvanized steel pipe. Orangeburg is an asphaltum covered fiber pipe. It is very light and can be sawed to length on the job, yet it is strong enough to use as an intake, if not subject to freezing.

Having built three ourselves, we now feel that we can contract construction on future weirs. The contracts will have to be on a per yard of excavation and per yard of concrete basis and will have to permit flexibility of design. Contract jobs will, of course, require close inspection, but they will tie up only one of our regular staff full time instead of practically everybody.

Calibration problems

Here at Hubbard Brook it is our practice to build prototype weirs. We calibrate them volumetrically at those flows low enough to do this, and use the formula values for higher flows. We have found, however, that volumetric calibration has its problems too. Having tried various sizes and shapes of calibration troughs that clamped to the blade, we have yet to find one that doesn't cause drawdown at certain flows. Apparently the trough eliminates free fall at certain flows, and drawdown results. Our latest, but as yet untried scheme, is a trough bolted and sealed (with asphalt) to the concrete trough below the V-blade. This will not interfere with flows over the blade in any way. If someone has a simpler way we would be happy to hear of it.

A real road at last

Having struggled through almost three years of operation on the Hubbard Brook Experimental Forest with an ancient, and beat-up logging road as our only means of access, our just-finished, permanent, all-weather forest road seems a real luxury. This first section of 1.8 miles brings us to our present area of operation, and construction is now under way on another section that will take us 1.8 miles farther into the watershed. We struggle on, but more comfortably now.

"Nor any drop..."

We have just been through--and are still in--an extremely dry season. Rainfall from July 8 to September 20 has been only 3.47 inches and from August 1 only .65 inches. Both of our operating weirs have yielded no flow for about a month. These are on 32- and 33-acre watersheds. The flow on 95-acre watershed

No. 3 was down to a mere trickle before a recent 0.5 inch rain. Fortunately, we had enough water for mixing cement, but not enough to interfere with pouring operations. Did someone say "good planning"?

Despite the dry weather, grass seeding of our weir sites and spur road in July produced a heavy cover. We used a mixture of orchard grass, red top, and creeping red fescue along with lime and 10-10-10 fertilizer.

Wanted: Design for a tilted windshield baffle

Is it necessary to tilt precip gages for efficient catch on the HBEF? Are windshields necessary? If the answer to both questions is "Yes", should we use horizontal or tilted windshields? We have set up a small study to find out.

Having accepted results from San Dimas and elsewhere as being generally applicable, it has been our practice to use tilted gages and windshields. But because standard windshield designs are all for horizontally mounted shields, that is what we are using. According to Helmers' Priest River study, tilted shields are much superior. If this is true here, we should be using them.

Our study will consist of 3 gages in one opening. All are standard, 8-inch gages. One will be tilted with a tilted shield; one will be tilted with a horizontal shield; and one will be horizontal with a horizontal shield. All shields will be of the same design; they will differ only in the mounting arrangement.

The gages will be operated for one or two years with the shields. Then the shields will be removed from the two gages that had the least catch, and measurements continued for another period long enough to establish differences in catch.

If the tilted gage and shield combination is found to give the greatest catch, we will adopt this as standard practice. If it is not, we will extend the study to other sites before deciding on a standard practice.

We have not yet completed installing this study because we have been awaiting experienced advice on the design of a tilted windshield. If any reader has a good one, we'd appreciate hearing about it.

Snow scales again

We noted with interest Bert Goodell's comments in the last semi-annual on the "Northeastern's" steelyard, the one that CAL Station originated. Checking with Chatillon about Bert's $90, one-tenth-inch Frazer Special (we were curious because we had been

quoted $175 for the same scale) it turned out that the price is $90 indeed, but without the backstart. So what backstart is worth $85? We ordered one.

We still wouldn't give up the steelyard. We use it in calibrating our weirs; we use it to check the inexpensive ($9) milk scales that we use to weigh our precip gages in the winter; and we'll have it to check our Frazer Special when we feel that the springs may be weakening.

Personnel and general

It's now Dr. Pierce. Bob spent the month of May at Madison, Wisconsin taking care of the final requirements for his Ph.D. in Soils, and was awarded the degree at this commencement. His thesis is titled, "Ground water, its nature, properties, and effects on forest growth."

Sartz moved up to Trimble's job in July, and Pierce to the assistant project leader spot vacated by Sartz. In the meantime, Raymond E. Leonard of Burlington, Vermont has been hired to round out the organization. He reported for duty on June 10. Ray comes to us from the staff of the University of Vermont. He is a graduate of Paul Smiths ranger school and the University of Vermont, and holds a Master's degree from the University of Helsinki.

Sartz and Pierce attended the Northeastern Forest Soils Conference in New Brunswick the week of August 18. The Canadians had planned an extremely interesting tour, and were otherwise most congenial hosts. Their scheme for evaluating site by classifying local climate (warmer than normal, normal, or cooler than normal) is thought-provoking. If only they had some data!

We conducted a show-me-trip at Hubbard Brook installations for a group of University of New Hampshire students under Dr. Harold Harker on July 19. We were accompanied by Mr. A. Saiyeh, Chief Forester of Liberia, and Mr. Fred Beane, Jr., correspondent for the New Hampshire Sunday News. Mr. Beane turned out a nice two-installment write-up with 6 pictures on the project. It appeared in the September 1 and 8 issues.

COASTAL OAK-PINE RESEARCH CENTER

The effect of spraying 600 inches of waste water a year (for the past 6 years) on vegetation and soils on the Coastal Plain of New Jersey is described in a paper submitted by Si Little, Howard Lull, and Irwin Remson (Geological Survey). Much of the natural vegetation was killed by the spraying. In its place has developed a rank growth of elder and many herbs--mostly pokeberry and weeds, as the smartweed. The forest floor is deeper and more mull-like than the unsprayed areas and has a much

greater earthworm population. The top 6-inch layer of soil in sprayed areas contained more organic matter and much more soluble nitrogen and phosphorus than the check areas. High rates of water absorption on the sprayed areas are associated with forest growth to the extent that it indicates an undisturbed soil condition and provides a protective forest floor to break the impact of the spray.

In mid-August, Horace Somes and Howard Lull visited the Newark, New Jersey and Bridgeport, Connecticut municipal watersheds. At the latter, a severe Matsucoccus scale is rapidly killing off sizable plantations of red pine. Possibilities of a study with the Division of Forest Insects were discussed with Phil Dowden to determine the effect of this infestation on water relations.

VIRGINIA PINE-HARDWOOD

This Center picked up a watershed project in September with the signing of a memorandum of understanding with the Bureau of Water Supply, Baltimore, Maryland and the Maryland Department of Forests and Parks. An experimental area containing four small watersheds was selected; we expect that two weirs will be built this year. A soil survey has been made of the area. Bernie Frank, Dick Trimble, and Ken Reinhart have served as consultants and advisors.

PUBLICATIONS

Physical properties of 134 soils in six northeastern states. A. R. Eschner, B. O. Jones, and R. C. Moyle. Northeastern Forest Exp. Sta. Paper 89. 11 pp., illus.

Forests guard the Potomac. Howard W. Lull and Ralph W. Marquis. Interstate Commission on the Potomac River Basin. 19 pp., illus.

How far from a stream should a logging road be located? George R. Trimble, Jr., and Richard S. Sartz. Jour. Forestry 55: 339-341.

A program of watershed-management research on forest lands in the upper Delaware and Susquehanna River basins. Howard W. Lull and Irwin C. Reigner. Northeastern Forest Exp. Sta. Paper 92. 33 pp., illus.

Snow and frost measurements in a watershed management research program. Richard S. Sartz. Northeastern Forest Exp. Sta. Paper 96. 9 pp., illus.

Forest watershed management research in Pennsylvania. Howard W. Lull. Pa. Forests 37: 41-42.

Manuscripts submitted

Influence of land use on time of soil freezing and thawing in the northeast. Richard S. Sartz.

Logging road seeding for erosion control in the White Mountains. J. C. Bjorkbom and G. R. Trimble, Jr.

The effect of type of soil frost on infiltration. G. R. Trimble, Jr., R. S. Sartz and R. S. Pierce.

Forest cutting and floods: early beliefs in Pennsylvania. Howard W. Lull.

A soil survey of forest land on the Hubbard Brook Experimental Forest. L. E. Garland, R. S. Pierce and G. R. Trimble, Jr.

Changes in woodland vegetation and soils from spraying large amounts of waste water. S. Little, H. W. Lull, and I. Remson.

A problem analysis and program of research for forest watershed management research in the White Mountains of New England. G. R. Trimble, Jr.

Calibration of five small forested watersheds. K. G. Reinhart.

PACIFIC NORTHWEST FOREST AND RANGE
EXPERIMENT STATION

Watershed Management Research
Semiannual Progress Report, April 1, 1957 - September 30, 1957

General

Last June our watershed research staff finally became fully manned when Gene Herring arrived for duty at the Siskiyou-Cascade Research Center. This gives us a total of six technical personnel and the following organization:

Headquarters--Portland

Mrs. Marjoree K. Hysmith, Secretary
Nedavia Bethlahmy, Leader, Bull Run Project
E. G. Dunford, Division Chief

Mid-Columbia Research Center

David D. Wooldridge, Wenatchee, Washington

Blue Mountain Research Center

Norman H. Miner, LaGrande, Oregon

Siskiyou-Cascade Research Center

Harold G. Herring, Roseburg, Oregon

Willamette Research Center

Jack S. Rothacher, H. J. Andrews Exp. Forest, Blue River, Oregon.

New Division in R-6

In August a new division of watershed management was set up in Region Six. We regard this as a very progressive step because it allows closer coordination of research and administrative activities in watershed management. Heretofore, responsibilities in the Regional office for matters pertaining to soil and water were scattered among

three other divisions. Chief of the new unit is Kermit W. Linstedt, formerly in charge of Fire Control for the Region. He has three sections: Hydrological Investigations with H. J. Fittinger in charge, Small Watershed Projects headed by Wm. E. Bullard, and a section of Water and Soil Management with Melvin H. Burke as leader.

Watershed Research Tour

In early September our gang wound up their recorder clocks good and tight and took off for three weeks to learn what other watershed researchers are doing in the West. Between September 8 and 28 we visited research areas in the Intermountain, Rocky Mountain and California Stations. Principal stopping points were Boise Basin, Wasatch Front, Great Basin, Fraser, Manitou, Beaver Creek Project near Flagstaff, Sierra Ancha watersheds, San Dimas and Central Sierra Snow Laboratory.

These are some of our dominant reactions:

1. Many of our watershed research people are excellent showmen and have ability to put across their story in a very interesting fashion. We are impressed with the general emphasis on public relations.

2. Watershed research carried on by the Western stations is broad in scope and should produce some very worthwhile results in a relatively few years.

3. Personnel engaged in watershed research at the areas visited are of exceptionally high caliber.

4. A trip such as we took has a great deal of value as a training device and we recommend it highly for that purpose alone.

VIP at HJA

On July 17 and 18 the Station was honored at the H. J. Andrews Experimental Forest by a visit from Secretary Benson. He was escorted into the region from Boise, Idaho by Regional Forester Stone and by E. G. Dunford, representing Director Cowlin. After a plane trip from Boise to Eugene, Oregon the Secretary spent a few hours looking at some of the problems on the Willamette National Forest adjacent to Eugene, including an hour with Bob Ruth and Jack Rothacher on the Andrews Experimental Forest. He obtained a birds-eye view of our

watershed and forest management research activities there and seemed generally interested in the program we have underway. We, in turn, were impressed with the Secretary's sincerity and friendly personality.

Blue Mountain Research Center

Training has been a primary function at the Blue Mountain Research Center during the past six months. Norm Miner attended a two-week course on snow hydrology given by the Corps of Engineers in Portland. This course provided background for planning snow studies in the Blue Mountains. The tour of western watershed research areas and local experience in range management techniques provided much additional training.

Weir Site Exploration

Weir site exploration was a major concern during the summer field season. Bedrock is as elusive on the Starkey Experimental Forest and Range as it is in many other areas. One, and possibly two, 90° V-notch, sharp-crested weirs will be installed on selected sites, during the summer of 1958 to provide information on the hydrology of small watersheds in the Blue Mountain area and later to evaluate effects of grazing and timber cutting.

Soil-vegetation Survey

In cooperation with the Soil Conservation Service, field mapping for a soil-vegetation survey of the experimental pastures on the Starkey Experimental Forest and Range was completed in June. Data from this survey will be very helpful in making final selection of test watersheds in the experimental pastures and will assist in evaluating the effect of grazing intensity and system of grazing on amounts of bedload deposited in the sediment basins.

Suspended Sediment Sampling

In May we began sampling suspended sediment in three streams as a part of a study of the effect of logging on erosion. One drainage which will not be logged is the control. Two other drainages will be logged this fall and winter.

As another approach, we plan to make detailed stream bank and stream channel surveys, giving special attention to areas disturbed during logging.

We could use a good method of continuously sampling suspended sediment. The filter and weighing device being developed by Harry Brown of the Rocky Mountain Station seems to be the best tool that we've heard about. If anyone has a better idea, let us know about it.

Publications

Miner, N. H., and Trappe, J. M. Snow interception, accumulation, and melt in lodgepole pine in the Blue Mountains. (To be released as a Station Research Note.)

Siskiyou-Cascade Research Center

Orientation and problem analyses have been the primary activities in the Siskiyou-Cascade Research Center. Gene Herring arrived in late June to fill the watershed research position and the ensuing three months have been largely devoted to acquainting him with the problems that exist in the area. During three weeks in September, Gene made the field trip with the rest of the watershed management research division.

Logging Roads are the Culprits

Considerable time was spent making a reconnaissance of logged settings which had undergone one wet season. For each setting, the general erosion classification, slope, logging method, petrologic formation and the apparent causes of accelerated erosion were noted. We realize that this, in part, is a subjective classification, but it is primarily intended as an orientation device. Tabulation is not yet complete, but the roads are once more emerging as the villains of the story.

A plan is being prepared to measure the quantity of soil loss on road cut-banks and to determine the influence of grass seeding on this loss. The initial step will be an attempt to develop an inexpensive runoff plot design which is suitable for roadside use, i.e. one which will not interfere with the ditch. One thought is to use rain-troughs to catch the runoff and channel it into 55-gallon drums. Any other ideas would be appreciated.

Municipal Watershed Problems - Junior Size

Water shortage problems seem to hit small user groups as well as the large ones in the Pacific Northwest. This fact seems to be especially evident in the Oregon Coast Range. Flows are not sustained by snow melt during the summer dry periods as they are in the Cascade Range.

In September Hallin, Herring and Dunford inspected a small coastal watershed serving domestic water for a group of 30 families near North Bend, Oregon. The watershed area, covering about 50 acres, was logged in the Twenties and has since grown up to a dense stand of red alder and salmonberry. Diurnal fluctuations are evident even from crude measurements with a 5-gallon bucket. In early September,

maximum flow of the stream is approximately 5 gallons per minute at 8 a.m., but by late afternoon is reduced to 3-1/4 gallons per minute.

Since there is almost no artificial storage in the system, these late afternoon depletions have caused curtailment of water use and the usual rationing problems. Need for some riparian cutting is indicated, but we are not in a position to state without reservation that significant gains will be made by such cutting treatments. We hope soon to inaugurate a watershed study in the coastal alder type which will give some quantitative answers for problems of this kind.

Willamette Research Center

The increased attention by the general public to water and watershed problems continues. A new Lane County Water Resources Committee has been formed with both the Willamette N. F. and the PNW Station represented on the committees. The most pressing problem of the moment is a study of the McKenzie River drainage where a sharp conflict has developed between use of the river for recreation and for power development.

Alsea River Study

The Oregon State Committee on Natural Resources has with legislative approval, initiated a study of the Alsea River Basin in the Oregon Coast Range. It is an ambitious undertaking to investigate all the water relations of a 334 square-mile drainage. Included will be water yields, rainfall patterns, streambed characteristics and spawning areas of anadromous fish, loss of water to domestic, industrial or agricultural uses, value of small impoundments, management methods in water conservation, soil-vegetation surveys and a study to determine the impact of logging upon the anadromous fishery resources, upon stream characteristics and runoff patterns and to determine ways to reconcile logging with conservation of aquatic resources. Results from this study will be the basis for future consideration in other watersheds of the state. To date $50,000 has been earmarked for the 1957-59 period. Donald W. Chapman, coordinating biologist, heads up the project.

Small Watersheds - H. J. Andrews Exp. Forest

With the help of Jerry Franklin, a student from OSC, a start has been made on the analysis of the backlog of streamflow data collected from our three small watersheds. We hope to complete the analysis this winter and determine the relationship between the control and the other two drainages. During the summer we completed the traverse of the three watersheds and find that they vary from 149 to 250 acres.

Watershed #3 has been set up as the first one to be treated. Prior to starting logging by the staggered-setting system, we will build the roads and study the resulting changes in flow and in sediment. About 4-1/2 miles of road were laid out to provide the necessary access for logging the drainage. Approximately 1-3/4 miles are within the experimental watershed. Survey has been started and we hope to complete the design this winter. Specifications for construction will adhere essentially to R-6 standards with special precautions taken to keep sidecast out of the stream channels.

Although timber sale roads are normally built by the purchaser, it will not be practical in this case since we plan to delay logging for at least a year. For this reason we have been authorized to use money appropriated for the timber access road program.

We hope to determine from this study just how much we disturb natural conditions on a drainage by constructing about 5 miles of road per section, and perhaps to learn how we can keep this disturbance to a minimum. It should be a good chance to study soil disturbance as some extremely difficult topography is represented.

First remeasurement of our three silt basins was completed in August. The basins were new and not well stabilized last winter, so it is probable that normal soil movement is considerably less than shown below:

Watershed Number	Area (Acres)	Sediment Accumulation per year		
		Total (Cubic feet)	Per Acre (Cubic feet)	Per Sq. Mile (Acre feet)
1	237	637.5	2.7	.0395
2	149	324.0	2.2	.0319
3	250	275.4	1.1	.0159

Periodic suspended sediment samples ranged from zero to 65 ppm. During normal flows, there is seldom over 3 ppm. A chemical analysis shows this to be soft water of higher quality than much of our municipal drinking water. Although 65 ppm was the highest recorded, we are certain that we have not yet sampled the heaviest sediment loads.

Interception Study

During the past summer an interception study was started on the Andrews Experimental Forest. Six plots are in operation, each adjacent to a clearcut unit in which a control gage is located. Under the timber, twenty points were randomly chosen within a 5-chain square. Four gages are read and moved after each storm until all points have been occupied.

The rotation will be repeated until sufficient data have been obtained-probably through next summer. Preliminary indications show that we are recording less than the 35 percent interception reported for Douglas-fir by Simpson in 1935.

Mid-Columbia Research Center

The watershed field season in the Mid-Columbia area started with a high-intensity rain and hail storm in early May. Mud and rock flows poured out of two major canyons south of Wenatchee and although no lives were lost, many were endangered. Storm and flood damage to property was over 1/2-million dollars in the Wenatchee area. Survey of the headwater's conditions on watersheds which caused the most flood trouble again indicated (as in the August 1956 storms) that overgrazing and poor logging practices were prime contributors to flash runoff.

Rehabilitation Studies

Initial fertilization and reseeding work was checked late in the summer and a fall replication of the same study installed. Soil amendments used in both trials were $N_1P_1K_1$, N_2P_1, N_3, $N_3P_2K_2$, and Aqua-GRO.

Soil treatment applied last spring produced a heavy growth of native vegetation at the expense of the seeded grasses (Pubescent wheat and timothy). Although the area when treated was almost devoid of vegetation, there was apparently a large supply of annual grass and weed seed in the soil. A combination of a wet spring and fertilizer stimulus, a very dense stand of annuals was formed, crowding out all competing seeded perennial grass seedlings. The criteria chosen for evaluating the experimental results (number of established perennial grass seedlings) turned out to be a poor one as there were very few seedlings. Next year plots of both study areas will be clipped and results evaluated on the basis of production of dry material.

Wyssen vs. Tractor

This fall, the first logging operation by a Wyssen Skyline Crane in the Pacific Northwest was completed on the Okanogan National Forest. In late August we made a study of this operation as well as a standard tractor operation in the same general area. Relative amounts of soil disturbance caused by each logging method were compared and soil samples obtained for subsequent analysis of changes in physical properties.

Three classes of soil disturbance were defined:

1. Litter disturbance. Indicated by breaking down of brush and reproduction, and disturbance to litter cover, but litter and soil cover not removed.

2. Shallow soil disturbance. Indicated by removal of litter and humus exposing the mineral soil to a depth of less than one inch.

3. Deep soil disturbance. Same as 2 above only disturbance exceeds the one-inch depth.

In the field a series of random transect lines were laid out and run on compass bearings generally parallel to the contours through the logged area. Transects were 3 chains log with 5 chains between transects. Along each transect, the linear extent of soil disturbance classes was measured by tape to the nearest tenth of a foot. Total transect length and distances between transects was paced.

Summary of Results of Soil Disturbance by Wyssen and Tractor Logging

Logging Method	Total Length of Transect	Disturbance Class							
		Litter		Shallow Soil		Deep Soil		Total Disturbed	
	Ft.	Ft.	%	Ft.	%	Ft.	%	Ft.	%
Tractor	10,296	786.0	7.6	669.4	6.5	1558.6	15.1	3014.0	29.2
Wyssen	11,088	718.0	6.5	237.3	2.1	326.7	2.9	1272.0	11.5

Soil Study

A basic study has been initiated to investigate the relationship of certain soil physical properties to soil-parent material and vegetation. At this stage of our study, vegetation is classed simply as forest and nonforest cover. Three parent materials were selected for initial tests; (1) Basalt types, usually forming a stable soil, (2) Swauk sandstones which form an erosive soil, and (3) granodiorite which also forms an erosive soil.

Five pairs of soil profiles were located on each parent material, one of each pair under forest cover and one under nonforest cover, (with the aid of aerial photographs). Soil profiles have been described and sampled by horizons. Following laboratory determinations are being made:

1. Bulk density
2. Porosity
3. Water stable aggregate
4. Mechanical analysis
5. Soil stability index
6. Organic matter

Field work has been completed but laboratory work and analysis of the data remain to be done. Initial results indicate that vegetation plays an important role in the development of many soil properties. This study will be completed and results published this fall.

Bull Run Project

Installation of stream gages on three small watersheds has been completed. Difficulties inherent in a major construction effort of this kind were overcome by the excellent cooperative spirit exhibited by the City of Portland. For example, an access road which is normally maintained by the Forest Service was made passable through the efforts of city employees.

Because of winter access problems, a small emergency shelter was erected close to the gaged watersheds. This cabin will now enable us to remain in the area overnight, rather than ski out of the watersheds after nightfall.

Evaporation Study

Scattered reports in the literature have indicated that evaporation from a free water surface can be substantially reduced through the use of cetyl alcohol. A small experiment was initiated to determine the possibility of reducing evaporation from reservoirs in the Portland area. The experiment consists essentially of measuring daily evaporation from two large evaporation pans, one having clear water, the other containing water covered with a film of cetyl alcohol. The data have not yet been analyzed, but a casual perusal indicates that fifty percent reductions in evaporation can be expected.

Logging Plans

The City of Portland plans to build a second large reservoir to take care of the water needs of an expanding population. The site is now being logged by contract. Originally, Portland required the logger to bulldoze the area down to base soil, even through the dam will not be built in several years. When we saw the results of the clearing operation and contemplated the potential erosion hazard we convinced the authorities that the slash should be burned, and the area seeded to grass.

The logging operation within the Bull Run area afforded us the opportunity to study rates of soil erosion following the high-lead system of logging. Subsequent salvage logging operations prevented our following the original plan. However, prior to this "gyppo" operation, aerial photos were taken of the logged area, and a ground survey was made of the soil disturbance created by skidding. Aerial photos will be studied this winter, and the results correlated with the ground survey.

Nature Tour

In late August Dunford took his bumps along with 8 others participating in a 2-day horseback trip in the Bull Run watershed. Participating were J. H. Stone, Regional Forester; personnel from the Mt. Hood National

Forest; Kenneth Anderson, Chief Engineer of Portland City Water Bureau; and Marshall Dana, ex-journalist and a prominent figure in water policy matters. Purpose of the trip was to get a first-hand look at some of the remote areas of the Bull Run watershed and to discuss needed management in this huge area of old-growth timber. Both administrative problems and research needs were examined. Even for the west, this municipal watershed constitutes an unusually large and continuous area of primeval forest. During the trip we saw a good part of a virgin stand which totals 3-1/2 billion board-feet. We also saw fish that had never been lured by a fisherman's hook.

Publications

Bethlahmy, Nedavia and Barr, George.
1957. Bull Run Watershed. Amer. Forests. 63(6):16-18, 62-64.

Bethlahmy, Nedavia and Anderson, H. Kenneth.
Watershed Research: Portland's Answer to Tomorrow's Problems. (Accepted for publication by Journal American Water Works Association)

SEMIANNUAL REPORT--APRIL 1957 THROUGH SEPTEMBER 1957
Division of Watershed Management Research
Rocky Mountain Forest and Range Experiment Station

Watershed researchers of this Station met at Manitou on May 6-10 to consider ways and means to learn about plants, climate, soils, and water. Bernie Frank, Ted Osborne, and Hank Sims were on hand to add zest to the discussion. Proceedings were processed and a few copies are available if anyone was missed.

Arizona has been making history in watershed affairs. A State Water Resources Committee has been organized and serves to stimulate both research and administration. Arizona faces great problems in obtaining and protecting water supplies and in allocating available water to the various uses. The Committee activities are bringing these considerations to public attention. Also assisting in public education is the Charles Lathrop Pack Forestry Foundation. In cooperation with the American Nature Association, they are beginning a program to inform the public about southwest resources, with water given the main emphasis.

RAPID CITY

Weather in the Black Hills has been unusually wet, water has been unusually plentiful, a project analysis was completed, and a site suitable for a soil moisture study was located and treated. These are the most notable events of the past 6 months as far as the watershed management project at Rapid City is concerned.

Precipitation and Streamflow Above Normal

Weather of the past 6 months started out unusually wet and unusually cold, particularly in the southeast part of the Black Hills. Lead, in the northern Hills, received 2.78 inches of precipitation in April, 0.18 inch below average, while Rapid City received 2.83 inches, 0.83 inch above average. Lead is in the part of the Hills where the highest precipitation is normally measured; while Rapid City, at an elevation of 3,200 feet in the foothills, usually receives much less precipitation.

May was the wettest month. Rapid City received 7.98 inches--5.21 inches above average, while Lead received only 6.03 inches--2.13 inches above average. The unusual geographical distribution of precipitation persisted through May. Mount Coolidge in the southeast part of the Hills received 8.41 inches of precipitation, the largest amount recorded at any station in the Black Hills during May.

The wet weather persisted through June. Rapid City received 3.99 inches--0.63 inch above average. A pronounced change in trend then occurred with July unusually dry and hot. Rapid City precipitation was only 1.55 inches--0.51 inch below average, and average temperature was 74.9 degrees F.--2.6 degrees above average for the month. August precipitation was 1.52 inches in Rapid City, about average, and average temperature was 71.5 degrees-also about average.

The unusually large amount of spring and early summer precipitation produced above normal streamflow. Most of the streams in the Black Hills lose a considerable part or all of their flow into sedimentary formations they cross before reaching the plains. But local people say that more water flowed across these formations and flow persisted longer than it has in years. Water flowed for weeks in channels that have obviously been dry for a long time. The newly constructed Pactola reservoir on Rapid Creek with a conservation capacity of 55,000 acre-feet had filled to almost 25 percent of capacity by August 31, a faster rate of filling than was anticipated.

Soil Moisture

A site with a suitable combination of timber and soil for a study of soil moisture under ponderosa pine was found. Exploratory soil moisture samples were collected in June. The soil is medium textured near the surface. The subsoil is heavier. Moisture contents decreased from about 30 percent by weight of oven-dry soil in the surface foot, to about 23 percent in the next three feet, to as low as 10 percent below six feet depth. The upper three to four feet were probably near field capacity but soil in the sixth foot and below was obviously under field capacity despite unusually abundant precipitation during April, May, and June. Using the soil tube samples for an approximation of bulk density, total moisture content of the upper six feet of soil was about 18 inches on June 4. Moisture content on June 19 was about 17 inches. Precipitation between the two dates was 3.65 inches. Since there was no evidence of percolation, total evapotranspiration during the period was equal to the reduction in soil moisture plus precipitation or about 4.65 inches. This is an average rate of 0.3 inch water use per day compared to water use by alfalfa of 0.2 to 0.3 inch per day in the western states. There was almost an inch more moisture in the 24 to 36 inch depth on June 19 than June 4 but there was two inches less from three to six feet accounting for the one inch net reduction soil moisture during the interval. The area supports a dense even-aged stand of ponderosa pine averaging about 6 inches d.b.h. Basal area is about 220 square feet per acre.

H. Orr

FORT COLLINS

Fraser Experimental Forest

Fool Creek

A heavy snow pack combined with a delayed spring produced unusually high and late peak flows. The peak flow of East St. Louis

Creek was the highest in 15 years of record, 26.1 c.s.m. That from Fool Creek was the second highest of record, 21.4 c.s.m., being exceeded only in 1952. Fool Creek peaked on June 28, East St. Louis on June 30.

With the treatment of Fool Creek completed in October 1956, this is the first year of post-treatment record of streamflow. Analyses show that during the snow melt period up to July 1, the flow of Fool Creek exceeded by 64 percent that predicted from its pre-treatment relationship to East St. Louis Creek.

Rather surprisingly, the peak for Fool Creek was 23 percent less than predicted, in contrast to a peak excess of 50 percent in 1956 when 80 percent of the treatment had been applied. The apparent explanation is that earlier melt associated with the timber removal had so reduced the area of snow cover that the warm period producing the peak flow was not as effective as it otherwise would have been. While it is expected that the treatment of the Fool Creek watershed will tend, in general, to increase peak flow rates, 1957 results are of interest in demonstrating that the reverse can also occur if the weather sequence is right.

The stripwise pattern of cutting on Fool Creek was designed to enable a study of the effect of strip width on snow accumulation. In each of the last two spring seasons, snow surveys have been made to compare the snow pack on 6-chain-wide strips with that on strips 1 chain wide. Both cut and uncut strips have been included in the areas sampled. In neither year has there been any indication of a difference in snow accumulation associated with strip width. However, the study cannot be considered conclusive because of the topographic and elevational heterogeneity inevitably present on a watershed.

Instruments

In a memorandum of August 7, R-Publications - General (Russian Translation), Bernard Frank refers to an electric hygrometer manufactured by the American Instrument Company and the Brown Instrument Company. For those interested, it is worth knowing that there are two other electric hygrometers now on the market that look promising and that cost only a fraction of the price of the one referred to by Bernie. One of these is supplied by Photo Crystals Inc. of Geneva, Illinois; the other by El-Tronics Inc. of Mayfield, Pennsylvania. Apparently neither has yet been as thoroughly tested as has the one referred to by Bernie, but appear well worth investigating.

Incidentally, the accuracy of the American Instrument Company hygrometer, in terms of relative humidity, drops off sharply at low temperatures: from 1.5 percent at 40° F to 10 percent at minus 20° F. In terms of dew point or vapor pressure, this decrease in accuracy is not nearly so pronounced.

Bernie refers to time changes in the calibration of the electric hygrometer and advises periodic testing by comparison with psychrometer readings. I believe that for studies where precision of measurement is important, calibration against the Alnor Dewpointer would be much more satisfactory. This instrument is made by the Illinois Testing Laboratory of Chicago, Illinois, is a precision instrument (especially the better grade model), and has no temperature limitations. However, it is not a convenient field instrument and is not adaptable for recording. Costwise, of course, the psychrometer is decidedly more attractive.

B. C. Goodell

Alpine Snow Studies

Ablation Rates

Observations of summer ablation have been made for the past three summers (1955-1957) at a snowfield located at an elevation of 12,500 feet on the eastern flank of Mount Evans. Weekly maps of the snowfield indicate little variation in the area of this field for a given date during the summers of 1955 and 1956. The heavy snows which fell during the spring and late winter of 1957 resulted in a much larger field however. When the observers tried to set up the weather instruments in late June, 1957, as they had been accustomed to doing in previous years, only a few inches of the 6-foot anemometer pole was visible above the snow.

Vertical ablation, as measured at poles imbedded in the snow, was found to vary only 0.3 foot per week for the three summers (see tabulation). In an attempt to correlate vertical ablation with something more meaningful than calendar date, the number of degree-days above 32° F. required to produce 1 foot of ablation were computed. For the summers of 1955 and 1956 almost identical values were found; however, the summer of 1957 proved to be different. For reasons which are not apparent, an average of about 10 percent more heat was required to cause 1 foot of ablation during the summer of 1957 than during the two previous summers. It is possible that there was a higher average albedo in 1957 than in 1955 and 1956. Heavy applications of water appear to brighten the surface of the summer snowfields and the summer of 1957 was a very rainy one. Unfortunately, no measurements of albedo were taken.

Vertical ablation, Mt. Evans snowfield

1955			1956			1957		
Date	Average ablation ft./wk.	Deg.days* per ft. ablation	Date	Average ablation ft./wk.	Deg. days per ft. ablation	Date	Average ablation ft./wk.	Deg.days per ft. ablation
6/22 6/30	1.5	45.2						
6/30 7/7	1.6	64.5				6/28 7/3	1.7	--
7/7 7/14	2.0	54.8	7/3 7/11	1.7	53.9	7/3 7/11	1.7	55.8
7/14 7/20	1.9	44.3	7/11 7/18	1.4	58.1	7/11 7/26	1.2	65.7
7/20 7/27	1.6	52.7	7/18 7/25	1.5	46.4			
7/27 8/3	1.8	55.9	7/25 8/1	1.2	63.8	7/26 8/2	1.7**	--
8/3 8/9	1.9	42.5	8/1 8/8	1.4	53.8	8/2 8/9	2.0	48.7
8/9 8/16	1.6	49.8	8/8 8/15	1.8	52.2	8/9 8/16	1.4	60.8
8/16 8/23	1.5	53.6	8/15 8/22	1.1	36.5	8/16 8/23	1.4	55.7
8/23 8/29	1.9	43.1	8/22 8/29	1.3	47.2	8/23 8/30	1.0	58.3
8/29 9/6	1.6	51.2	8/29 9/5	1.4	--			
9/6 9/14	1.3	59.2	9/5 9/11	1.3	--			
Ave.	1.7	51.4		1.4	51.5		1.5	57.5

* Degree days above 32° F. as measured in W. B. cotton region instrument shelter.

** This value was taken twice in computing the average since it covers a two-week period.

Air-snow moisture exchange

An experiment to determine the net moisture exchange between the atmosphere and an alpine snow surface was carried out during August 1957. The snowfield was at an elevation of about 11,500 feet and had a southern exposure.

Two types of plastic lysimeters were used in this experiment: one type was made from heavy plexiglass; the other from opaque 20-mil polyvinyl sheeting. The plexiglass units were 16" in diameter and about 16" tall. A perforated, hemispherical portion divided them into two sections. The upper section was loaded with snow, the lower acted as a catchment for the melt water. A hole in the bottom of the cylinder served as a drain. The upper portion of each unit was loaded with snow. The entire unit was then weighed and buried to its rim in the snowfield. At intervals during the day the units were pulled from their position in the snowfield, weighed, drained, reweighed, recharged with additional snow, weighed again, and replaced in the snowfield. Four "runs" of from 2 to 4 days each were made during late July and August, using 2 to 4 pairs of lysimeters. A few runs were made with all units exposed and a few were made with one unit of each pair shaded from direct sunlight by a conical metal hood.

Preliminary analyses of these data show the moisture exchange to be small. Maximum condensation and evaporation rates were about 1 ounce per hour on the surface of 1.4 square feet. Much lower rates were the general rules for the periods of observation. Condensation exceeded evaporation both in frequency of occurrence and in net amount.

The polyvinyl lysimeters actually served as waterproof liners for pits dug into the snowfield and backfilled with a weighed amount of snow. Two pits, 5' x 10' x 3'deep, were dug, lined with plastic, and refilled with snow. A plastic tube carried melt water to a 50-gallon drum from which it could be poured for frequent weighing. One of these large lysimter units was set out on August 20 and another on August 21. Both were taken out on August 29, 1957.

Each unit was loaded with 4860 pounds of snow. Melt water was weighed 5 or 6 times each 24 hours and at the end of the experiment the snow remaining in the plastic was dug out and weighed. Records were kept of air temperature, wind travel, and dew point within 12" to 14" of the snow and of temperature, humidity, and wind travel from 4 to 6 feet above the ground nearby. Records were also kept of the ablation taking place on the snowfield and of the precipitation.

The net moisture exchange for the 8-9 day period of this experiment averaged 0.35 inch of water per week for one lysimeter, and 0.27 inch of water per week for the other.

More extensive analysis of these data should permit the tabulation of melt rates for several periods of the day, as well as a check of some of the physical equations for predicting evaporation and condensation based on weather data.

M. Martinelli

Manitou Experimental Forest

Major effort here this past field season was a root study of eight species to obtain information to guide future work. Species studied were (1) ponderosa pine, (2) Douglas-fir, (3) quaking aspen, (4) kinnikinnick(Arctostaphylos uva-ursi), (5) mountainmahogany (Cercocarpus montanus),(6) Arizona fescue (Festuca arizonica), (7) mountain muhly (Muhlenbergia montana),and (8) lodgepole pine. The plants were growing on residual soils derived from: (1) Pikes Peak granite, (2) Madison limestone, and (3) Sawatch quartzite, except for lodgepole pine which is found only on granitic soils at Manitou.

In order to study the true rooting habits of the tree species, rather than rooting habits during developmental stages, individuals in the small pole class were selected. (Ages, determined by ring counts, varied from 65 to 110 years.) Representative mature individuals of the low-growing species were selected in proximity to the selected trees. A backhoe furnished trenches from which to base operations. Watershed men, armed only with ice-picks and mole-like tendencies, did the rest.

Nothing startling was observed in excavation of root systems of the low-growing species. Pronounced differences were noted in root systems of the tree species between and within the soil sites.

The deepest soil in which root systems were excavated was that from Madison limestone - a soil that is typically a deep, fertile loam or stoney loam. The soil is calcareous and contains a high percentage of fragmented rock. Substratum consists of rock fragments with fine soil material within the fissures.

Aspen and ponderosa pine here were the deep-rooted species. The aspen (age 95 years) penetrated to a maximum depth of 4.2 feet with a working depth of 3.8 feet. The ponderosa (age 65 years) penetrated to a maximum depth of 5.7 feet with a working depth of 4.0 feet. The striking difference between these species was the lateral extent. The aspen root spread to a distance of 48 feet, the ponderosa pine spread to 20 feet. Douglas-fir (age 75 years) had an occasional root penetrating to a depth of 4.9 feet, but working depth was held to approximately 2.0 feet. Lateral spread was 21 feet.

Soils derived from Pikes Peak granite, the most extensive soils at Manitou Experimental Forest, are coarse, gravelly, loose soils developed from disintegrating bedrock. The soil is slightly

acidic and generally not fertile. The site selected for the root study was trenched to approximately 6 feet where impenetrable parent material was encountered. Rooting depths of all tree species were quite similar and are apparently limited by site rather than inherent characteristics of species. As in limestone soils, the aspen was the far-reaching plant with a lateral spread of 31 feet as compared to ponderosa pine, 12 feet; Douglas-fir, 11.5 feet; and lodgepole pine, 16 feet.

Soils derived from Sawatch quartzite are very shallow, fine sands, low in organic matter and of low fertility. Depth on the site studied varied from 6 inches to 30 inches. Site is definitely the limiting factor of rooting as all species had roots trailing along the parent material. Lateral extent of aspen roots here was 20 feet; ponderosa pine, 19.2 feet; and Douglas-fir, 10 feet.

The area occupied by aspen roots on all soils is probably the most interesting feature of this study. Perhaps this aids in understanding why aspen is sometimes thought of as the villain of our western watersheds.

H. W. Berndt.

GRAND JUNCTION

Black Mesa Watershed Studies

The first year of grazing treatment is now underway on the three Black Mesa experimental watersheds. Light, moderate, and heavy grazing are being applied to gaged watersheds in an effort to learn some of the relationships between plant and ground cover (as influenced by cattle grazing), and the production of water and sediment.

The experimental area lies at about 9,800 feet and has grassland, spruce-fir and aspen cover.

The year of 1957 has been characterized by unusually heavy precipitation. The peak snow pack on the watersheds came on April 12. It was 73.6 inches deep and had a water content of 28.2 inches. Precipitation from the time of peak snow pack until the end of snowmelt runoff totaled a little over 9 inches, indicating total precipitation for the season in excess of 37 inches. Runoff has not yet been computed.

During runoff, water samples were collected for sediment determinations.

Plant and ground cover are being measured by means of permanent 3-step transects.

Water Use Study

In 1957 we are continuing the water use study which was initiated in 1955 and described in earlier issues of the semiannual report. The object of the 1957 measurements is to determine relative amounts of summer soil moisture withdrawal under aspen, spruce, and a mixed grass-weed cover. Gravimetric soil moisture determinations are made in the spring and again at the end of the growing season, the difference being considered the amount of water used by the vegetation. Each type is being sampled in three different areas, with 7 samples per area. One-foot samples are taken in a depth of 8 feet.

H. E. Brown

ALBUQUERQUE RESEARCH CENTER

Change in Personnel

In July, Ed Palpant transferred to the Pike National Forest, where he took up duties as Assistant Ranger, stationed at Woodland Park, Colorado.

Bob Thompson, a graduate of Colorado State University, joined our research center in July, filling the vacancy left by Palpant's transfer. Bob has the distinction of being the only student from CSU that completed all of the undergraduate courses recommended for the watershed management curricula.

New Publications

Three publications concerned with watershed management in the Southwest and New Mexico, in particular, have recently been released:

1. Symposium on problems on the Upper Rio Grande - an arid zone river - 1957.

2. New Mexico water conference. October 31 - Nov. 1-2, 1956.

3. The water challenge of the Southwest - C. L. Forsling.

Copies of all three publications may be obtained by writing directly to our research center - until our supply is exhausted.

The Rio Grande publication contains 9 papers presented at the International Arid Lands Symposium and conference held in 1955 at the University of New Mexico in Albuquerque and a concluding article by Peter C. Duisberg on post-symposium developments and the job ahead. This is an important publication and a necessary addition to watershed management libraries. Other papers and recommendations from the International Arid Lands meetings are available in the printed book entitled, "The Future of Arid Lands", edited by Gilbert F. White, publication 43 of the American Association for the Advancement of Science, Washington, D. C., 1956.

The New Mexico Water Conference publication contains most of the papers presented during the State-wide Water Conference held in Milton Hall on the New Mexico A & M Campus on October 31, November 1 and 2, 1956. This conference was attended by leaders in business, agriculture,and government from many areas in New Mexico and adjacent States. The presentation of the various aspects of the water problem in New Mexico and the exchange of ideas at this conference has helped to focus the attention of all of the people in New Mexico for the need of formulating, at an early date, a definite program of water development and conservation. This processed publication contains 15 papers on various aspects of water, including supply, use, economics, law and even watershed management.

The third publication is a reprint of an address delivered by Clarence L. Forsling, Director of Forest and Watershed Conservation Research, Charles Lathrop Pack Forestry Foundation and the American Nature Association, at the 12th annual meeting of the Soil Conservation Society of America, Pacific Grove, California,on August 30, 1957. In case you younger folks haven't heard of Forsling before now, here is a quick look-see at his past record: Formerly Director of the Intermountain Experiment Station; Director of Research , Forest Service, Washington, D. C.; Director of the Grazing Service; and Head, Interagency Southwest Field Committee.

San Luis Watersheds

In the last issue we discussed methods of measuring soil movement over land slopes. This past summer we tried our proposed method of measuring soil elevations. Bob Thompson describes the field work in detail.

E. J. Dortignac

Soil elevation measurements on the San Luis watersheds

Soil elevation measurements are now underway on the Rio Puerco experimental watersheds. The results we hope to obtain from these measurements are: (a) soil movement patterns, and (b) rates of aggradation and degradation. These results will then provide information needed for designing land treatments as well as for measuring the influence of grazing and mechanical land treatments on soil movement.

On each of 3 watersheds in the experimental area, transect grids were established adjacent to the sandstone bluffs on the alluvial fans. The grid areas were chosen by: (a) similarity of micro-site, (b) proximity to natural breaks,and (c) accessibility. The size of the grid area was more or less fixed by the size of the area meeting the above criteria; however, transect lines were arbitrarily discontinued downslope on the alluvium where size of gullies prevented easy crossing on foot. The grid lay-out was oriented so that one axis was perpendicular to the general drainage pattern.

Metal stakes (re-bars, 1/2" x 36") driven 30 inches into the soil, mark the 100-foot square grids.

Using an engineer's level, Philadelphia rod and metal tape, point elevation measurements were taken at 5-foot intervals between stakes. The stakes were used as turning points; therefore, a reading was also obtained on each stake. With time and weather as limiting factors, transect lines perpendicular to the drainage pattern are the only ones along which readings are being made at the present.

Measurements were first attempted using a target on the rod; however, this proved too slow and tedious to warrant the added accuracy. By removing the target and waving the rod rather than using a rod level, an additional problem was encountered. Unless the instrument-man could obtain the reading with the first wave of the rod, a sizable increase in the reading was noticed which was attributed to soil compaction by the rod. To alleviate this problem, a 32 gauge, 5" by 5" galvanized metal plate was attached to the bottom of the rod in such a manner that it would allow the rod to rock without moving the plate.

Permanent bench-marks were established in sandstone bedrock on each grid area. By taking the initial backsight and final foresight on a bench-mark, an error of closure will be obtained for each set of grids. Double turning points were used to reduce the error of closure.

J. R. Thompson

FLAGSTAFF FIELD UNIT

Activity has been the watchword this summer. Over 30 storms on the Beaver Creek watershed during July, August, and September have produced, along with January through June precipitation, 32 inches of precipitation in the pine type (7,300 ft. elevation), 20 inches in the alligator juniper type (6,300 ft. elevation), and about 16 inches in the Utah juniper type (5,500 ft. elevation). This in Arizona where long-term averages are about 20, 15, and 8 inches, respectively. Possibly the "drought" has subsided. All is green and lush.

Clarence M. (Butch) Skau joined our staff in June. Butch came to us from Michigan State University and is focusing his efforts on the soils in the juniper type. He will use one of our problems as a subject for his doctorate thesis.

The Arizona watershed management project (Beaver Creek project) is in full swing. We have installed, on 9 watersheds, 20 standard precipitation gages, 6 recording precipitation gages, and 3 hygrothermographs in standard weather stations. Trapezoidal Venturi-type flumes (modified WSC flumes) have been installed on 8 or 9 watersheds on the project area. All nine are to be completed by October of this year.

Several flumes have received flow this summer with peak discharges of around 2 second-feet. The one exception to this occurred on August 13 on a watershed of about 1,700 acres. Here, about 390 acres received 2.50 inches in 1 hour and the remaining acreage about 1 inch. Rainfall began at 11:50 a.m. At 12:35 a small trickle began in the channel and through the flume. At 12:40 a wall of water (estimated to be 4 feet high) hit the flume and by 12:50 the flow was 380 second-feet. Flow continued at a diminishing rate until the following day. An afternote to this terrific flow was that 15 miles downstream none of the flow was recorded or seen.

Willie R. Curtis was fortunate enough to have been there and recorded, on photographs, this wall of water and the high flows. Anyone interested in seeing these photographs, please write.

Our pine-pole interception study has netted us a vast amount of data, which as yet has not been analyzed. I can say we have found that stem flow begins on ponderosa pine poles (4.5-11.5 in. d.b.h.) with about 0.20-inch storms. At our next writing we hope to say more about storms and interception. Out of curiosity we have chemically analyzed this stem-flow water. Does anyone need such data?

E. F. Aldon

TEMPE RESEARCH UNIT

Effects of wildfire in a pine-fir forest at Sierra Ancha

On July 6, 1957, a wildfire burned 60 acres in the upper southeast portion of the South Fork of Workman Creek. The burned area is in the upper and most level portion of the watershed. Stream channels are not well defined and no perennial water rises in this portion of the watershed.

During July 1953, 18 randomly located cross sections had been mapped in the South Fork stream channel above the gaging station. The uppermost cross section was about 500 ft. below the lower edge of the burn. Profiles were run across the randomly located sample plots, 5 of which have been relocated in the burned area. On July 15 and 16, 1957, three profile lines 132 feet long and 33 feet apart were run through each of four, reseeding plots (0.4 acre in size) prior to the first rain after the fire.

The first storm on the burn was one of the heaviest summer rains measured at Workman Creek. Rainfall varied from 3.50 to 4.05 inches at two storage gages in the area. A recording raingage outside the burn indicated approximately half of the rainfall occurred in 30 minutes. This storm moved most of the ashes of the area, but deposited part of them in depressions on the flat area before reaching well defined stream channels, and part along the main channel where debris caught and formed additional barriers that held sediment.

Cross sections and profiles were remeasured the first week of September 1957, and sediment accumulation for 1 year was removed from the stilling basin above the 90 degree V-notch weir gaging station.

Sediment removed from the weir pond totaled 818 cubic feet, mostly in the upper part of the basin. About 80 percent of the capacity of the stilling pond was filled, but almost no material was deposited against the weir wall.

Sediment deposited and held in the stream channel varied generally with distance above the weir. Profiles closest to the weir pond showed overall deposition, while those immediately below the burn showed erosion. Changes in channel cross sections between 1953 and 1957 are as follows:

Distance above weir to cross section	Cut	Fill	Net Change
ft.	sq. ft.	sq. ft.	sq. ft.
344	6.0	39.6	33.6 fill
577	0.4	5.8	5.4 fill
783	2.2	3.1	0.9 fill
958	2.0	7.1	5.1 fill
1117	0	16.0	16.0 fill
1392	0.8	15.6	14.8 fill
1534	2.0	2.6	0.6 fill
1714	9.5	13.0	3.5 fill
1970	4.2	2.6	1.6 erosion
2170	1.0	1.9	0.9 fill
2333	0	5.8	5.8 fill
2351	4.1	10.6	6.5 fill
2511	4.7	1.0	3.7 erosion
2738	2.4	2.2	0.2 erosion
2904	6.6	5.7	0.9 erosion
3127	11.6	5.5	6.1 erosion
3332	0.8	1.8	1.0 fill
Average			4.8 fill

Average fill for the 17 cross sections was 4.8 square feet. Even where there was heavy deposition there was usually some scour and deepening in the bottom of the stream channel.

Sample plot profiles within the fire area were reestablished on 5 plots. Four lines were near 100 feet in length, one line was 32 feet in length. Measurements were taken at two foot intervals. One hundred and ninety-eight points measured in the 5 plots showed an average soil loss of 0.023 foot. In addition litter and duff lost averaged 0.123 foot. Plot data are as follows:

Plot No.	Net Average Erosion per point	Basal Area of Trees 1956 (after logging)	1957 (after fire)	Average Crown Intercept (ft.) per 100 ft. (Fern etc.)	
	ft.	sq. ft.	sq. ft.	1953	9/9/57
76	0.061	27.99	0	4.20	17.22
77	.010	23.04	10.33	.17	1.22
79	- .017 (fill)	39.15	0	.17	4.57
80	.008	52.98	45.97	0	0
81	.043	35.56	17.20	10.36	11.40

The profile lines in the reseeding plots were measured at 1-foot intervals. One hundred sixty-one points fell on rocks and logs and were not included. Erosion occurred on 1074 points and fill on 361 points. Net erosion from the 1435 points averaged 0.015 foot.

Total change in soil depth was computed by omitting signs from the total number of points. Erosion is an average for the points showing soil loss. Fill is an average for the points showing deposition. Net is the difference between erosion and fill, divided by the total number of points. This measurement should give net erosion or fill for the profile line.

Plot No.	Line	No. Points	Average Change Per Point Ft. Total	Erosion	Fill	Net	Slope Between Upper & Lower Line (percent)
1	upper	117	.048	.053	.033	.031)	
1	middle	103	.049	.040	.039	.022)	15.3
1	lower	124	.038	.032	.054	.007)	
2	upper	127	.032	.032	.037	.029)	
2	middle	129	.033	.034	.032	.012)	6.5
2	lower	130	.028	.024	.034	.001)	
3	upper	119	.036	.037	.035	.019)	
3	middle	114	.027	.018	.042	-.003 fill)	8.3
3	lower	125	.027	.025	.030	.006)	
4	upper	100	.031	.026	.045	.010)	
4	middle	120	.026	.024	.031	.011)	7.3
4	lower	127	.043	.041	.060	.034)	

Average soil loss from the 1633 points measured in the re-seeding plots and sample plots was .016 foot or loss of nearly 1 acre-foot. About 2 percent of this can be accounted for in the weir pond, and 40 percent in the channel. The other 58 percent is believed to be deposited in depressions and lower slopes, where measurements have not yet been made.

L. R. Rich

Measurement of evapotranspiration

A field model of the infrared evapotranspiration apparatus was constructed and one preliminary test was completed. The chamber is 6' x 6' x 8'. It is made of polyethylene film on a light wooden framework, and can be assembled in the field by two men in about 5 minutes. Ventilation is by a gasoline-powered blower. A small gasoline-powered generator supplies 110 volts A.C. for the analyzer and sampling pumps. All equipment fits easily into a pickup truck. The preliminary study was a comparison of transpiration rates of salt cedar and of soil Bermuda grass cover growing on a seepage site along an irrigation canal near Tempe, Arizona.

J. P. Decker

Ecological Studies

A satisfactory method has been found to germinate tamarisk seed rapidly. The initial studies using soil as a medium and lightly covering the seed gave no germination. Very high germination was obtained by placing seed on moist filter paper in covered Petri dishes.

No method has yet been developed to obtain satisfactory germination of seed of Baccharis glutinosa or to explain the reasons for its low germination. Further studies along these lines are planned.

Tamarisk seed loses its viability in several months if stored in warm temperatures and even more rapidly if stored at high temperatures. Seed have been collected at biweekly intervals since late spring. Germination tests have been run at the same interval using all lots of seed. Results are shown in the following table:

Date of collection	Germination Percent															
	Immediately after collection	Weeks after Collection														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
4/12/57	23	--	--	--	--	20	--	39	27	--	6	--	1	--	0	--
5/10/57	--	--	--	--	94	94	--	98	--	92	--	72	--	20	--	0
5/31/57	93	92	--	89	--	74	--	34	--	17	--	3	--	0		
6/6/57	98	100	95	--	94	--	60	--	40	--	12	--	0			
6/14/57	--	87	--	93	--	63	--	10	--	0	--	0				
6/28/57	--	100	--	94	--	96	--	96	--	38						
6/28/57 1/	--	98	--	94	--	2	--	0	--	0						
7/19/57	93	--	91	--	79	--	6									
8/9/57	--	--	92	--	63											
8/19/57	85	--	98													

1/ Seed stored in greenhouse.

Seed furnished us by the A.R.S. which had been held in cold storage through the winter of 1956-57, gave 14 percent germination in April of 1957. In all later tests, almost no seed germinated.

Tamarisk seeds germinate quickly, almost all activity being accomplished in 24 hours after the seeds are wet. Studies have shown that they germinate under a variety of conditions: while floating on water, in the absence of light, in cold temperatures, and on soil almost at wilting point if the air is moist.

The seedlings rapidly push out from the seed coat, usually completely separating from it. The radicle forms a ring of anchor hairs which fasten the seedling to the ground. The entire seedling turns green and the split between the colyledons becomes marked before the end of twenty-four hour period. The stem soon becomes upright supported by the anchor hairs. The first true root forms slowly in the center of the ring of anchor hairs and it may be a week or more before the seedling is firmly anchored and the roots capable of absorbing moisture from soil drier than saturation.

When seedlings were grown so that roots were visible through glass, the major root grew only an inch in 2 1/2 weeks. During this early period the tiny seedlings will float if submerged and die quickly if the soil surface becomes even slightly dry. To insure survival the soil must be kept constantly wet by sub-surface irrigation. In addition temperatures must be high; laboratory temperatures (78°-82°) are not high enough to develop the seedlings.

To observe seedling growth under several conditions, 5 seeds were sown on 7/22/57 in each of eight clay pots containing silt soil. Four of the pots were kept in the laboratory (78°-82°F)and four in the greenhouse where the temperature exceeded 100° F. practically every day. At each location half of the pots were left standing continuously in trays with about half inch of water, thus keeping the soil nearly saturated. The other half of the pots were watered daily by placing the pots for 4 hours in the trays. As a further study, half were watered with tap water and half with distilled water. The following table gives the growth in centimeters of the largest individual:

	Laboratory				Greenhouse			
	Watered 4 hours daily		Kept saturated		Watered 4 hours daily		Kept saturated	
	Distilled	Tap	Distilled	Tap	Distilled	Tap	Distilled	Tap
Date	Centimeters							
7/29	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
8/6	0.2	0.2	0.2	0.2	0.1	0.1	0.5	0.4
8/13	0.2	0.25	0.3	0.3	0.1	0.1	0.8	0.75
8/19	0.3	0.3	0.4	0.4	0.1	0.1	1.7	2.0
8/27	0.5	0.5	0.5	0.5	All Dead	0.15	4.6	2.3
9/4	0.5	0.5	0.7	0.7		All Dead	7.3	4.8

Conditions to insure survival of seedlings are to be found in the field under a very specialized set of conditions, such as slowly receding summer flood flows, along irrigation ditches, and around the banks of reservoirs.

Establishment of wells and climatic station

Wells have been established and water-stage recorders installed for measurement of ground-water levels on a study plot along the Salt River. One of these wells, which is some distance from the river, shows a marked daily fluctuation in water levels. This suggests high evapotranspiration losses.

A climatic station for recording temperature and humidity has been set up in the Salt River experimental area. A very erratic record is being obtained due to fluctuations between moist-cool river-bottom air and hot-dry desert air nearby. For example, the temperature rose 26 degrees between midnight and one o'clock when wind movement from the desert replaced the cool air along the river.

J. S. Horton

Chaparral Management Study

A study of chaparral vegetation in Arizona has been initiated since July 1. This work will include ecological, hydrological, and management studies of watersheds characterized by a chaparral cover in Arizona. Several investigations already underway in the chaparral will serve as important leads. These include the effects of fire and grazing on shrub-grass watersheds at Sierra Ancha, and the chaparral watersheds on the 3-Bar Game Management Unit.

The watershed studies will deal with the influences of grazing and certain controlled shrub eradication methods (fire, chemicals, etc.) upon runoff and retention and soil erosion. This, again, entails the possible establishment and preservation of a shrub-grass balance which will allow for maximum grazing potential by game and livestock as well as optimum water yields from chaparral watershed lands. Chemical eradication research will be carried out in cooperation with the Agricultural Research Service.

A reconnaissance trip has been taken into the Prescott and Tonto National Forests in order to locate additional chaparral watershed study areas.

J. B. Secor

A book worth reading

IRRIGATION DEVELOPMENT AND PUBLIC WATER POLICY, by Roy E. Huffman, Associate Professor of Agricultural Economics, Montana State College. The Ronald Press Company, New York. 1953.

Watershed researchers who have not done so will be interested in reading this book. A nice tie is made between watersheds and the irrigated valleys below. A variety of subjects is discussed including public land policy, water rights, project organizations,

finances and economics, river basin development, public interest, and the relation of irrigation to natural resources from the standpoint of State, nation, and foreign countries.

The book is written largely from the viewpoint of an economist. The attitude of the author is well expressed by the quote: "To the extent that public funds are used, society is entitled to assurance that land reclamation is carried on where it will realize the greatest return per dollar spent." Moreover, the need for reclamation is stated to stem from President Roosevelt's conservation program which he considered to radiate from two central points, namely, homes and the forests.

A chapter on water rights is well written yet one is left wondering about the legal status of water rights. Those working in watershed management may have cause to wonder for whom they are working, who will benefit from their results, and how any watershed management improvements are going to be financed under our present water laws.

The author adopts the following attitude with regard to the place of irrigation in the national economy: "The major importance of irrigation in many areas of the West lies in promoting stability and flexibility in production rather than in adding to the quantity of goods produced." This attitude was tested in the Great Plains where the great drouth placed considerable emphasis on the importance of integrating all land uses in order to achieve a suitable economy.

The multiple use concept of Cooke is also adopted by the author. This is: "It is a denial of Nature to regard water or any of the developments normally associated with water as single problems. Water is one part of the great complex we call Nature. When we make an alteration in any one part, we automatically alter in some degree all the other parts." Moreover, Huffman states: "...the nation will get only one chance to make its river basins and it had better do a good job." He goes on to say that watershed management is primarily a public responsibility, largely because watershed management yields little direct revenue and is largely beneficial to others, hence there is little incentive for private capital.

The misconception of the general public regarding the economic nature to water is well stated as: "...there is a tendency to rating water third only to air and sunshine." However, the growing pressure on the water resource, its greater scarcity and the resulting higher demand, implies that water ranks much higher as an economic good.

The author considers four variables to determine the ability of resources to support the human population. These are: (1) the natural resources available, (2) the level of technology, (3) the

economic and social organization, and (4) the population. The bearing that each of these variables has on the water economy is discussed in detail. Incidentally, the author is not a Neo-Malthusian. He is of the opinion that agricultural technology is an effective answer to any such "alarmist thinking".

Much concern is expressed with regard to the need for a national water policy. In the author's words: "The United States has never had a resource policy related to the needs of the nation at any particular time or in the long run". He is in favor of planned production, such that the producers on the land"...do not have to kill themselves and their resources to make a living and perform their social functions". He goes on to say that, "Contrary to the popular view that national planning must be detrimental to our democratic system of government, it may be essential to the continued strength of the American system. A nation which does not look to its future needs for resources and plan for their use in the public interest is likely to find itself in difficulty. History indicates that nations which deplete their resources are more likely to become involved in changes in government, or to disappear entirely, than are those which maintain a stable resource base".

H. G. Reynolds

SEMIANNUAL REPORT

Division of Watershed Management Research
Southeastern Forest Experiment Station

April - September, 1957

COWEETA HYDROLOGIC LABORATORY

RESEARCH

New Work

Water Balance. Coweeta Watershed No. 17, site of the well-known clear-cut study, was planted to white pine in 1955. This watershed has a northern aspect and it was felt that more substantial information would be derived from the study of hydrologic effects of coniferous stands if a south-facing watershed were similarly planted. Therefore, Watershed No. 1 was cleared last fall and planted to white pine this spring. In ten years time it should be possible to begin hydrologic comparisons between conifer and native hardwood forest on two aspects. Eighty man-days were required to plant approximately 40,000 seedlings on the 38-acre drainage.

Precipitation Network. Work has started on the proposed re-examination of the Coweeta raingage network, with particular emphasis on strengthening rainfall totals for individual watersheds. Several additional raingages have been installed in order to test the changes in rainfall with elevation due to orographic effects.

Evapotranspiration Relations at Coweeta. A preliminary study has been made on a consolidated analysis of the water balance data from four treated watersheds. Three years' data from Watershed No. 1, in which the cove hardwood site was clear-cut in 1954, have shown some inconsistency with results from other Coweeta clear-cut studies. It appears from the accumulating evidence that the relationship between stream yield and the percent of area cut is far from linear. Fortunately, there will be an opportunity to check the increased streamflow from Watershed No. 1 under a 100 percent clear-cut before the pines now planted there have time to significantly affect the stream hydrology. Comparisons can then be made between this watershed and others at Coweeta to determine whether there are fundamental differences among the watersheds.

In line with the plans to investigate the application of Penman's method of estimating evapotranspiration to Coweeta, calculations are being made to determine the effect of different slopes and aspects on the radiation component (R_A) in Penman's method.

Integrated Watershed Management Studies. A resurvey of Watersheds No. 40 and 41 is in progress. These drainages are being converted on a long-term basis to managed forest stands. One is to be managed for maximum water production with supplemental timber products, and the other for maximum timber production--both with minimum damage to water quality. Observations on streamflow and water quality are expected to show success or failure in attaining the goals set for the two studies. In the meantime, the present re-examination of the experimental design is to bring the working plan into line with current practices in timber and watershed management.

Studies in Progress

Data are still being collected on the first of a series of interception studies proposed for different forest types on Coweeta. Average values are needed for several forest types to strengthen our interpretations of the water balance equation. The current study is exploratory and particular care is being taken with methods of instrumentation and stem flow analysis. A system of rotating throughfall gages is used and stem flow is measured in 55-gallon drums with water level recorders attached.

Results from several Coweeta experiments have indicated a need for more information about the hydrologic effects of partial clear-cuts. The concept of clear-cutting blends over naturally into the general problem of the influence of specific stand variables on water yield. A two-year-old treatment on Watershed No. 22 is expected to throw light on both of these areas of investigation. A 70-acre drainage was 50 percent "clear-cut" (actually deadened with sodium arsenite) in 33-foot strips running at right angles to the stream. The plan was to remove half the basal area of the stand from half the ground area without discrimination between species, diameter classes, or forest types. Results in terms of water yield will not be available until three or more years of record have been collected. Present activities are restricted to collecting data and recutting the strips each year.

On Watersheds No. 17 and 1, brush cutting to release the pine plantations is a continuing problem. Dense patches of blackberry briars appear to be particularly effective in choking out two-year-old seedlings. Chemical sprays are being experimented with to determine their usefulness on this and other brush control problems at the laboratory.

Studies on Standby Status

With publication of papers on the effect of cutting understory vegetation (Johnson and Kovner, "Effect on Streamflow of Cutting a Forest Understory," Forest Science, Vol. 2, No. 2, 1956) and clearcutting with regrowth permitted (Kovner, "Evapotranspiration and Water Yields Following Forest Cutting and Natural Regrowth," Proc. Soc. Amer. For., 1956), Watersheds No. 19 and 13, respectively, are being held in an inactive status. Only routine rainfall and runoff records are being observed. Published and unpublished data from these experiments will be used in consolidated studies of evapotranspiration.

Long popular with visitors, the three demonstration studies of exploitive use of steep mountain land on Watersheds No. 3, 7, and 10 have been retired from treatment. The mountain farm, terminated in 1953, has shown remarkable recovery under rehabilitation. Almost completely revegetated, it appears in better hydrologic condition than the neighboring woodland grazing area from which cattle were removed about the same time. The destruction of the forest soil by trampling in the woods has created a condition slow to recover by comparison with open farm land under the combined influence of frost and the annual growth of herbs and grasses. With closure of the last timber sale on the exploitive mountain logging experiment in January, the poor land use phase of the Coweeta research program is substantially completed. Effective methods for rehabilitating the eroded logging trails and badly damaged forest stands on Watershed No. 10 remain to be planned.

GENERAL

Dr. Larry Walker from the University of Georgia at Athens accepted a summer assignment working on a reappraisal of Coweeta's integrated watershed management study. His duties included the preparation of background material for a revised working plan.

Pete Black returned in June from a semester in residence at the University of Michigan, Ann Arbor, where he completed the course work for his Master's degree. He is continuing work on the interception study which is the subject of his thesis.

During the summer, Lloyd Swift, a graduate student from North Carolina State University, worked here on a Master's thesis problem. His problem is concerned with evapotranspiration relations--specifically, solar radiation values for watersheds with different slopes and aspects.

Dave Striffler received his Master's degree in June at the University of Michigan, Ann Arbor, on the basis of a soil moisture study carried out at Coweeta last summer.

Construction on US Highway 23 and 441 was completed in June, allowing easier access to and from the laboratory from both directions. In addition, plans are under way for improving and paving portions of the three-mile access road to Coweeta.

Meeting and Training Trips

Region 8.-- Whelan and Hewlett worked closely with Hine, Rossoll, Clapp, Spector and Friedrick of Region 8 in planning and carrying out Forest Service participation in the Annual Meeting of the National Watershed Congress held in Atlanta, Ga. on Sept. 23-25, 1957.

Region 7.--Whelan assisted Region 7 in setting up procedures for making forest hydrologic condition surveys on the Delaware Basin. An Inter-Agency comprehensive study is being made of the Delaware at the request of the Corps of Engineers.

Varney of Region 7, Ilch and Morey of WO, and Whelan conducted a Hydrologic Training Session for new men in Region 7 and in the States of Virginia and West Virginia engaged in small watershed and flood prevention work during the week of April 15, 1957 at Blackwater Falls State Park, W. Va. Hewlett at the same time visited the Fernow Experimental Forest and discussed soil moisture and evapotranspiration problems with Reinhart.

Whelan, as secretary, attended the Annual Meeting of the Work Group Committee on the Kentucky Strip-Mining study on June 4-5, 1957 at Lexington, Ky. The group consisted of 25 people from 13 Federal, State, and Interstate agencies and one University. The group reported on and reviewed work done during the past year and made plans for next year. A preliminary report will be prepared for the first two years of operation and presented at the June 1958 meeting.

Other Meetings.--Whelan also attended the following meetings: Annual Meeting of the Alabama Academy of Science at Jacksonville, Ala. on April 26, 1957.

Annual Meeting of the American Geophysical Union at Washington, D. C., on April 29-30, 1957.

Meeting of the Tennessee Section of the American Society of Civil Engineers at Asheville, N. C., on May 17, 1957.

VISITORS

Among visitors were Mr. Bernard Anderson and Jack Kern of the Washington Office, Mr. T. C. Menne, of the Union of South Africa Dept. of Water Affairs, and Professor D. C. Midgley of the University of Pretoria, Union of South Africa. In addition, several students from foreign countries have come to Coweeta for short training periods.

PUBLICATIONS

Kovner, Jacob L. "Evapotranspiration and water yields following forest cutting and natural regrowth," Proc. Soc. Am. For., Memphis, Tenn.

Hewlett, John D. "Coweeta Hydrologic Laboratory" (brochure to be used for the National Watershed Congress in Atlanta, Sept. 1957).

Whelan, Donald E. "The Effect of land use on runoff" (Address before the conference of the Alabama Academy of Science, Jacksonville, Ala., April 1957. Submitted for publication in the proceedings of the meeting.)

Work continues on the forthcoming Coweeta guide book. Every effort is being made to make it a timely and useful addition to Coweeta literature. Plans are being formulated for preparation of a twenty-five year progress report on the whole research program at Coweeta.

DISCUSSION: Soil Moisture Sampling by the Gravimetric Method: Is It Practical in Forest Hydrologic Research? (By John Hewlett)

It is with some temerity that one approaches the problem of soil moisture sampling. So much intense study has been devoted by competent workers to the methods used in obtaining and interpreting soil moisture values that further general discussion of the difficulties may seem unprofitable. However, the need for accurate measurements of soil moisture continues to be particularly acute in watershed management research. Methods which are perhaps satisfactory to the needs of land irrigators and others investigating practical problems in engineering have been developed, but there remains much to be desired in the application of present methods to plant-soil-water research. Attempts to evaluate the soil moisture component in forest hydrology have met at best with only partial success.

The largest unknown quantity of water in any estimate of storage components on a watershed of fairly deep soils is soil moisture. In order to budget water through the soil profile, the emphasis in moisture sampling must be placed on quantitative rather than qualitative values, the latter being typified by estimates of soil tilth, water availability, or soil traffica-bility. A rough determination of moisture can lead to a satisfactory qualitative estimate, as when a farmer squeezes soil in his hands to learn if it will cultivate properly, but such techniques--or perhaps any method which assesses water as a percent of soil weight--are inadequate for balancing the input-output relations on an experimental watershed.

Research into water balance relations would be greatly benefited by the development of techniques for securing accurate and continuous records of soil moisture on a volumetric basis. Researchers in watershed management have reluctantly but repeatedly concluded that the most reliable method is gravimetric sampling, in spite of the fact that the development of instruments for measuring moisture *in situ* has progressed.

A relatively intense program of soil moisture sampling has been under way at Coweeta for nearly two years. The studies have been exploratory, intended to compile periodic records for index plots, to develop techniques for sampling suited to our particular research problems, and to determine the value of soil moisture records as an aid in interpreting other hydrologic data. Three specific objectives of this work has been (1) to establish seasonal trends in soil moisture under a hardwood forest, (2) to test for differences in soil moisture depletion rates when the forest is removed, and (3) to test for differences between various levels of elevation from 2000 to 5000 feet above sea level. Gravimetric sampling has been used throughout these studies.

Soil moisture sampling in watershed research must meet certain conditions to be of real value:

(1) The values must be on a volumetric basis.

(2) The soil profile must be sampled deeper than it generally is in other investigations--extending preferably throughout the zone of active root penetration.

(3) If the watershed is to be balanced, many sampling sites will be required.

(4) Several years of record are sometimes needed to meet the objectives of type-conversion and evapotranspiration studies.

Each one of the requirements above has difficulties associated with it which severely limit the usefulness of the gravimetric sampling method. Inches of water are convenient volumetric units to deal with because they allow the expression of rainfall, soil moisture and streamflow in common terms which are independent of the land area under discussion. An unsolved problem in gravimetric sampling is the accurate conversion of percent-by-weight values to volumetric units. Accurate conversion can be made only if the bulk density of each sample is determined. Other considerations, such as excessive disturbance to the sampling plot, renders this impractical. Average bulk density secured from a few undisturbed samples near or within the plot must be used to convert the individual determinations of percent moisture by weight to percent by volume. It was suspected formerly that changes in soil moisture would directly affect these values because of the fluctuations in bulk density known to exist as a result of these changes. However, Reinhart (Occasional Paper 135, Southern Forest Experiment Station, July 1954) has shown that this effect does not enter into the calculation of inches depth from percent by weight and bulk density. On the other hand, the deviation in bulk density of an individual soil moisture sample from the average bulk density previously determined invariably introduces a proportional error into the calculated volume of water for that sample. This constitutes an added source of error in the volume estimate over and above the natural variation in the distribution of water through the soil profile

being sampled. Of course, both these sources of error could be controlled by greatly increasing the number of moisture samples, but studies so far indicate that the number necessary would be prohibitive in time and expense.

As a specific example of the above effect, suppose the average bulk density for a sampling plot is 0.75, with a standard deviation of 0.15 (not unusual in the upper foot of a forest soil). Suppose further that a sample is extracted from a point where the actual bulk density is 0.60 and the moisture percent by weight is 25.

Percent Soil Moist.	Actual Bulk Density	Percent Moist. by Vol.	Average Bulk Density	% Calcul. fr. Aver.	Error (Diff. in % Vol.)
25	0.60	15.0	0.75	18.8	+3.8

Thus as much as one-half inch difference in soil moisture per foot depth of soil can frequently be expected between the calculated and the actual soil moisture for the point sampled. Variability in the upper foot of a forest soil makes moisture values from this source particularly susceptible to this type of error.

In watersheds with shallow soils--that is, less than two feet to relatively impermeable material--forest soils can probably be sampled with devices other than the King tube or Veihmeyer tube now in use for gravimetric sampling. Forest trees root deeper and draw water from deeper storage than do agricultural crops and pastures in areas with deep soils and adequate rainfall. It has long been recognized that watersheds with deep soils are best suited for basic hydrologic research. Nevertheless, the necessity for withdrawing samples from a depth of six to eight feet places considerable strain on plot design, instruments, and the time required to obtain the samples. During drought conditions (when we are often particularly interested in the lower horizons) it becomes very difficult and sometimes impossible to extract samples from the deeper layers.

Due to the variability in soils and vegetation, particularly on steep mountain watersheds, the number of random samples necessary to establish a useful moisture value for the watershed as a whole renders such an approach entirely impractical. Gravimetric soil moisture sampling in the forest can be carried out satisfactorily only on a plot basis, or some modification of the plot basis. The plot can be so located as to serve as an index of the area under study. Because of time and mechanical difficulties in scheduling and collecting samples, the plot must be small enough to yield a satisfactory average value from only a few point samples. A system of plots designed to test a specific phenomenon should be capable of being sampled in one day by the manpower available. This puts natural limitations on the size of the plot and the number of samples per plot. Therefore, in studies requiring periodic soil moisture information the plots are almost invariably overworked. The

bulk densities and hydrologic properties of the upper foot of soil are gradually changed, and even if loose soil is packed into the moisture sample holes, there remains an indeterminate effect on the distribution of water in the lower horizons.

The life of an index plot cannot be considered longer than one year under a periodic sampling schedule, it being understood that the plot must be kept small enough to prevent undue influence from normal variations in soils. By a system of alternate sampling of sub-plots, the plot may perhaps be enlarged and the life extended, but at the expense of a more complicated analysis, more samples per plot, and a greater error in the estimate. It is now being proposed at Coweeta to make a further attempt to demonstrate differences in the soil moisture regime with differences in elevation using a plot design in line with that latterly described.

When error due to natural variations in soil physical properties affecting the water regime are added to error resulting from methods of calculation and procedure, we can expect to establish values for soil moisture in a six or eight foot profile only to the nearest 2 or 3 inches. In the proposed soil moisture elevation study, we are looking for differences in total soil moisture depletion rates of an order of one to two inches per month (based on a hypothesised summer-time range in daily evapotranspiration rates of 0.15" to 0.20"). The question is, do we stand a reasonable chance of demonstrating the presence or absence of such a difference with even the best designed gravimetric sampling techniques? The same question might be asked concerning a type-conversion study--for instance, the effect of the total removal of forest cover on the soil moisture regime. With an indicated reduction of 1.25" per month (perhaps 2" in summer and less in winter) in E_T rates, the differences to be detected by the sampling techniques would be of the same order of magnitude. Because of the complications of frequent rains, it is necessary to work within a reduced range to total values, to show the nature and the differences in the moisture depletion trends. In rare seasons at Coweeta, when monthly differences are allowed because of lack of rain to accumulate toward the end of the growing season, the results of slightly different daily rates may show up in the moisture data. However, these are probably abnormal rates, difficult to interpret in the light of the hypothesis, and also difficult to investigate since it will not be known when such a season is to occur.

In summary, obtaining soil moisture values for mature forest soil, with its roots, rocks, rodent burrows, insect holes, and high organic content, is proving to be a problem which may constitute an impasse in forest soil moisture investigations for hydrologic purposes--at least until improved instrumentation is available. As is well known, some of the current methods for measuring moisture <u>in situ</u> show great promise--for example the neutron scattering devices--but the bugs in the instruments and their high cost have caused a reluctance to use them on other than a trial basis.

In the meantime, considerable funds are being tied up in studies involving gravimetric sampling techniques--studies which quite frequently lead to inconclusive or questionable results. If we conclude that for purposes of hydrologic research, the measurement of soil moisture is a must, then are we justified in planning further studies involving methods which demonstrated that their best is probably not good enough? Why not divert the research effort toward perfecting and developing skill in using the newer instruments, or, in short, why not concentrate more on methods of measuring soil moisture.

PIEDMONT RESEARCH CENTER

GRAVIMETRIC MEASUREMENT OF SOIL MOISTURE

To be of value in watershed work, moisture in the soil must be expressed in inches of water, preferably available inches. The percent of water on a weight basis is of little value for it does not tell us the quantity of water present. The use of inches of total or available water allows a comparison of the soil moisture regime of two or more soils, cover types, land-use treatments, etc.

When considering a soil moisture study by gravimetric methods, obvious problems which face the researcher are how many bulk density and soil moisture samples are necessary to give the desired results. These two items are important for they limit accuracy, determine the size of plot necessary, and in the end, determine the feasibility of the study. The natural variability of soils and resulting problems of accuracy are common to most soil groups in the country. In the southeast coastal plain, for example, 15 bulk density samples from each of four contiguous quarter-acre plots show considerable variation in the surface two inches of soil. The table below gives the number of samples necessary to ascertain given levels of accuracy for each plot.

Plot	Mean Bulk Density	Standard deviation of B. D.	Number of samples (t=0.05) necessary to hold BD within ±	
			0.10 of true mean	0.05 of true mean
1	1.12	0.070	1	9
2	1.03	0.182	16	61
3	1.00	0.114	6	24
4	1.05	0.152	10	43

The number of individual soil moisture samples necessary to achieve a given degree of accuracy depends on the amount of variation in the moisture from point to point and in the depth of soil being sampled. Generally speaking, fewer samples are required from deeper depths than from the surface in Piedmont soils. Six samples taken to a depth of 48 inches within a 132 foot square plot illustrate this.

Depth of sample in inches	Number of samples necessary to estimate soil moisture to within + 10% of true mean
0-6	113
6-12	25
12-18	17
18-24	6
24-30	6
30-36	7
36-42	4
42-48	4

It should be pointed out, however, that it may not be necessary or desirable to hold all depths to the same degree of accuracy. Some samples contain such small amounts of water that an accuracy of ± 10% of the true moisture content causes unnecessary work. The table below gives data for a sandy surface soil and a clay subsoil. An accuracy of 20% for the surface gives deviations, in inches of water, less than an accuracy of 10% does for the subsoil. In this case, if we are willing to accept 20% for the surface 6 inches of soil the number of samples needed would drop from 113 to 29.

Depth	Bulk Density	Accuracy	Pw of moisture in soil at wilting	: saturation	Max. deviation from true soil moisture at wilting	: saturation
Inches		Percent	Percent	Percent	Inches	Inches
0-6	1.38	± 20	4	18	± 0.06	± 0.30
42-48	1.50	± 10	19	35	± 0.17	± 0.32

Gravimetric sampling can be used to test for differences in soil moisture. However, if the difference one looks for are small, it may be necessary to take such a large number of samples that the experiment becomes impractical. If it is feasible to carry out the study, careful thought should be given to the accuracy to be attained so that the natural variation of the soil does not obscure the results.

If a large sampling program is undertaken it is necessary to lighten the load by improvement in techniques. Two things we are doing at the Piedmont Research Center cut down appreciably on laboratory and computation time. (1) An automatic balance is a great time saver because one man can weigh and record (to the nearest tenth gram) 5 or 6 samples per minute. (2) We have all of our sampling cans tared to 40 grams (by use of solder) and this permits mental subtraction when converting from gross to net weight.

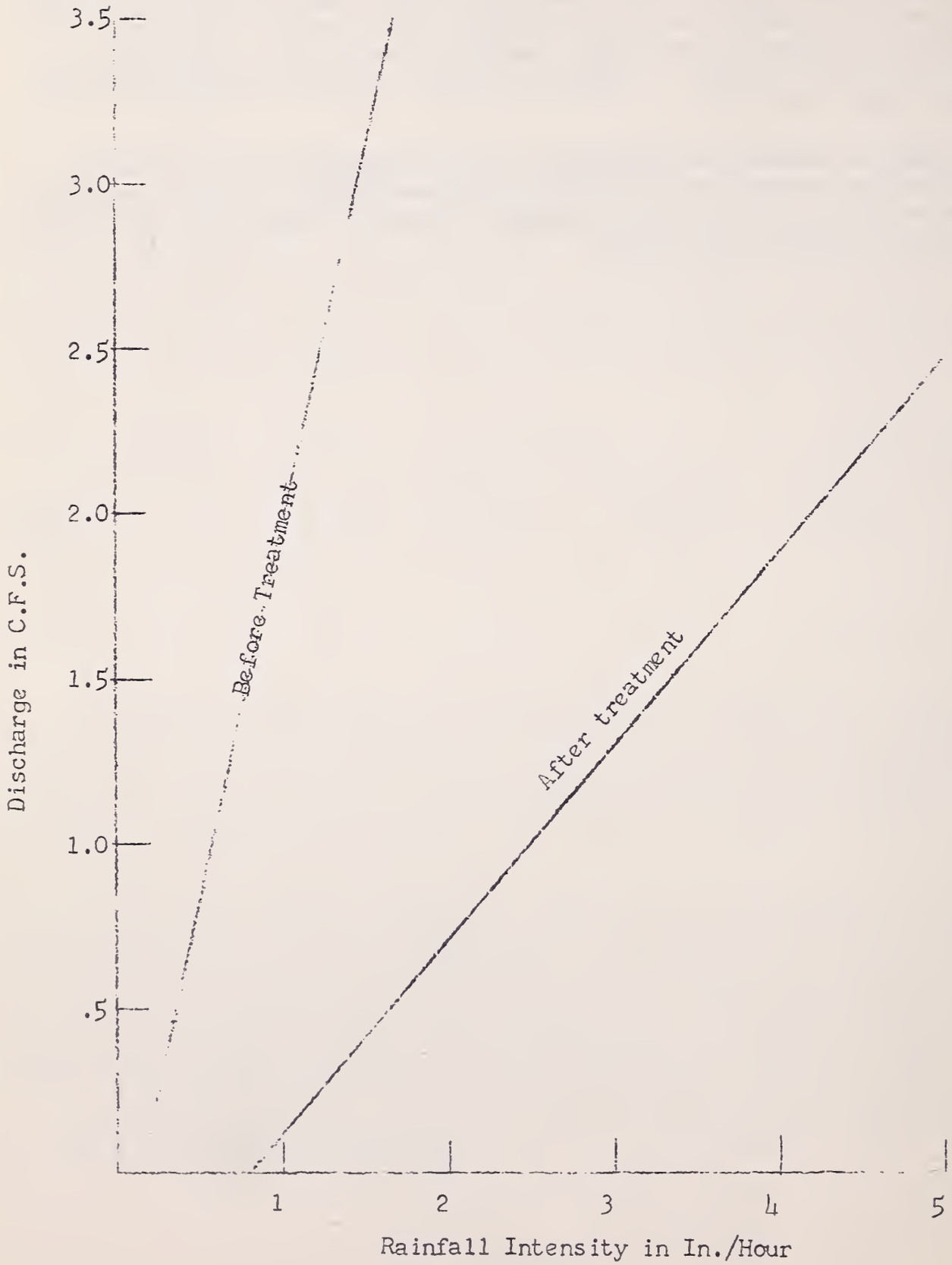
We would appreciate hearing of other time saving ideas which will speed the work of gravimetric sampling.

EROSION CONTRON MEASURES HAVE A PRONOUNCED EFFECT ON PEAK DISCHARGE

An analysis of storm flows from Watershed #1 on the Calhoun Experimental Forest indicate that peak discharge has been greatly reduced by an erosion control treatment (see Quarterly Report for April-June 1956, and SEFES Annual Reports for 1955 and 1956 for details and pictures). Briefly, the treatment was applied to a 15 acre watershed, four and one half acres of which were gullied and actively eroding. The treatment consisted of smoothing the gullies, fertilizing, seeding to serecia and crotalaria, and mulching with pine litter. A number of small diversion ditches and check dams were also constructed.

Figure 1 illustrates the effect of the treatment on peak discharge. For summer type storms, peak discharge has been greatly reduced. The reduction was least for the high intensity storms (77%) and greatest for the low intensity storms (up to 100%).

Figure 1.--Peak discharge (C.F.S.) for maximum 10-minute precipitation intensities



SEMI-ANNUAL REPORT
Division of Watershed Management Research
Southern Forest Experiment Station

April 1957 - September 1957

General

The Southern Station's Station Hydrologic Research Committee met at Vicksburg on July 10 - 11 for the purpose of reviewing the technical aspects of the Vicksburg program. This Committee consisted of the soils and watershed management researchers of the Southern Station, the Vicksburg technical staff, a representative from the U. S. Army Corps of Engineers, and Dr. Robert Campbell, head of the Watershed Management Research Division of the Southern Station.

The group considered a series of prospectuses for proposed studies. A discussion of problems, techniques, and instruments was pointed and constructive. The group felt that the Committee should be continued and another meeting will be held sometime next year.

At Hot Springs, Arkansas, on May 27 - 29, H. D. Burke, R. S. Campbell, G. M. Judson, James L. Smith, S. J. Ursic, P. R. Wheeler, and Robert Zahner from the Southern Station; Robert Baker, C. A. Friedrich, and Al Spector from Region 8; and Dewey Thomason from the Soil Conservation Service, met to discuss and firm up forest survey procedure in obtaining supplemental watershed and site productivity data.

The Committee agreed upon the following procedure to be used in collecting data from forest survey relating to hydrology and soil productivity:

1. Diagnostic tallies will be taken on every 16th or 20th plot throughout the state. On each of these plots, the following data will be taken from at least two locations within each plot.

   a. Hydrology - litter depth, humus depth, and humus type. Definitions to be taken from Morey's Classification.

2. Classification of past land use.

   a. Forest

   b. Cultivated or pasture within last 20 years.

3. Evidences of past fire.

   a. Period classification and 2 or more intensity classifications will be catalogued.

      Definitions are to be obtained from the Fire Division.

4. If evidences of cutting exist, list by growing season as follows:

   a. Current season, 1 year, 2 years, 3 years, 4 years, 5 or more years since cutting.

5. If evidences of grazing exist, intensity of grazing will be catalogued by a system to be devised by Campbell.

6. Slope percent will be catalogued using the following grouping:

   a. 0, 1-3, 4-9, 10-19, 20-29, 30-39, 40-59, 60, and over.

   b. Aspect will be listed by use of 8 octants of 45° each beginning with north as 0. The first segment will range from 0 to 45°, the second from 45° to 90°, the third from 90° to 135°, the fourth 135° to 180°, etc. If the plot is located in the Coastal Plain, aspect will simply be listed as indeterminate.

   c. Position on slope will be listed under one of the following headings:

      (1) Bottom, 1/3 up the slope, middle 1/3, and upper 1/3.

7. Total tree height and total age of a number of dominants and codominants will be taken on each plot. The number will be determined by Survey personnel. Average crown diameter will be also obtained.

8. Depth to the first inhibiting layer will be catalogued under one of the following groups:

   a. 0-6, 6-12, 12-18, 18-24, 24 inches and above.

9. Texture of the inhibiting layer 6" within such layer will be determined by mechanical analysis of sample.

10. Texture of the soil 6" from the surface will be determined by mechanical analysis of sample.

11. Soil series will be determined where possible--if it is not possible to so identify soil series in some plots, soils on the plots will be segregated into the hydrologic class by texture and depth of soil.

12. Records will be kept by river basin, by county, and by Survey unit.

In view of the large amount of cooperation expected from private companies on the forthcoming survey, and in view of the soil productivity classification scheme already worked out for the Coastal Plain province, it was decided that a more intensive productivity survey would be made in the Coastal Plain region than in the other three physiographic provinces. The number of diagnostic plots to be taken in the Coastal Plain, in addition to every 16th or 20th plot, (perhaps every 4th plot) will be determined at a later date.

Since there is likely to be no active cooperation from private companies within the Ozark province, it was suggested flood control might be interested in aiding the collection of hydrologic data within that province, to permit determination of sampling errors involved. Data collected would consist of litter depth, humus depth and humus type only. This data would be obtained from every survey plot. Details of this cooperation, if forthcoming, will be worked out at a later date.

It was suggested that Smith and Zahner might work with the survey crews in visiting the diagnostic tallies within their localities. This would consist of a yet to be determined number of plots for the Coastal Plain, and approximately 50 plots within each of the Ozark and Ouachita Mountain provinces. Zahner indicated that it might be possible for him to visit all or most all the plots within the Coastal Plain. Smith indicated that he would be able to work with the survey crews only to the extent that existing program committments permitted.

The Arkansas Forest Survey is expected to get underway late this year. Field crews would possibly be ready for training by September to November. Since diagnostic tallies would be taken by supervisory personnel only, the job of training is not expected to take an abnormal amount of time.

The suggestion was made that perhaps arrangements could be worked out with the Soil Conservation Service to furnish consulting advice to the Survey in classifying soil series on the plots. This would be especially important within the mountain provinces. Zahner indicated that he would be able to classify series on plots within the Coastal Plain.

It was realized by all members of the subcommittee that a larger number of plots than the 1/16th or 1/20th contemplated would be desirable. However, it was also felt that this beginning would provide valuable data for use in resource planning by industry, as well as state and federal agencies. It should be especially useful to such agencies as the Water Resources Planning Board of the State of Arkansas, flood control surveys, and the small watershed programs. It is expected that it will be of equal importance to the National Forest in aiding the gathering of data for the soil and water inventory. In addition to the above, it will provide a basis for determination of the variability between plots

and provide the basis for determination of the number of plots needed for subsequent studies. It is expected such a survey will also point out "sore spots" to be considered in the research program of the research centers within the state.

Personnel

New personnel at Vicksburg are: Dr. Forrest Stearns from the Purdue faculty as our ecologist; Mrs. Nellie Landblom from Colorado State University faculty as our statistician; Teruo Yamamoto from Indiana University as our watershed geologist, and Bill Krumbach from Michigan State as a forester (Forest Influences). Three aids have also joined the staff; these are: Howard Holler, Bill Monk, and Bob Hollingsworth.

Publications

Work accomplished by the Vicksburg staff has been presented in various journal papers, office reports, progress reports, etc. Some of the information is readily available, but much has had very limited distribution or is in the form of office reports in the files.

In the course of informing and indoctrinating new personnel, the staff has brought together a summary of the work accomplished through June 1957, including a complete bibliography of the publications, station notes, etc. A limited number of copies is available to those who might be interested.

Manuscripts in preparation or being edited at Tallahatchie are:

Thames, J. L. Estimating soil moisture over extended areas. Being processed.

_____ Hydraulic inserter for soil moisture units. Submitted to Soil Science.

_____ Inexpensive raingage calibration weights. To be submitted to Journal of Soil and Water Conservation.

Vicksburg Research Center

After six years as an Infiltration Project, Vicksburg is now a full-fledged Research Center.

The Vicksburg work has recently been organized into four sections as follows:

1. Methods and Techniques - responsible for the design, investigation, and testing of tools and techniques to obtain reliable measures of soil characteristics and environmental factors which affect hydrologic conditions and trafficability (of military vehicles). We particularly need new techniques in wet soils.

2. Problem Soils - investigates hydrologic and trafficability problems unique to certain soils and upon which special attention must be focused before reliable moisture-strength prediction can be obtained.

3. Environmental Factors - measures the effect of climate, plant cover, elevation, physiographic features, latitude, and land use upon hydrologic condition and trafficability.

4. Soil Moisture-Strength Prediction - translates the findings of hydrologic condition studies, to the refinement, testing, and application of soil moisture-strength prediction methods, and points out specific added information needed to increase the range and reliability of the prediction of soil moisture and strength.

Each of the sections has been set up under a project leader, and the various studies in each section will be undertaken separately, or with correlative studies, in another section, when expedient.

Studies currently in progress at Vicksburg are:

1. Improvement of core samplers for bulk density and remolding indexes.

2. The use of liquid nitrogen in sampling of wet soils and calibration of wet soil sampling devices.

3. Sampling intensity for determining horizontal and vertical variation of physical properties in selected soils.

4. Correlation of physical factors as they apply to soil strength-moisture relations on "Prediction Development Sites."

5. Application and testing of revised average prediction relations from analysis of data from "Prediction Development Sites." (Tentative standard relations have been evolved for predicting soil moisture, and this study is to analyze the method and the data used to develop the method, with the ultimate goal of increasing the accuracy of the predictions).

6. Soil strength-texture relations for soils with water tables within a foot of the surface. (Concerned with soil textures that cause a trafficability problem when saturated, and the loss of strength of these soils under very wet conditions).

7. Development of a map or system for the application of transition dates. (Ability to detect the time when moisture depletion rates change is vital to the prediction system. It is probable that these changes occur with an ordered shift in phenological events, and this line of thought is being pursued).

Most of these studies are in the study plan or pilot stages at the present time. All should be in full swing at the time of the next report or some completed, and new studies underway.

Tallahatchie Research Center

Watershed studies.--Construction of the second battery of three small watershed installations was completed and operations were started as of July 1, 1957. The three drainage units are from two to three acres in size and have a cover of depleted and commercially worthless upland hardwoods. This cover type is representative of a vast acreage of the forests in the South. The 1948 Forest Survey figures for the 15 north central counties in Mississippi give some idea of the extent of this forest type-condition class. Of the 1,250,000 acres of upland hardwoods (upland hardwood and upland hardwood-pine types), 845,000 acres support stands made up largely of poor quality material and noncommercial species. More than 60 percent of the upland hardwood stands are sparsely stocked and provide inadequate cover and forest floor conditions for optimum soil stabilization and watershed protection. Past cultivation, grazing, indiscriminate cutting practices, and wildfire have all played a role in the impairment of the water regulatory functions of these lands.

Almost one-third of the upland hardwoods occupy ridges and upper slopes that could provide far greater returns if converted to pine. Each year an increasing number of acres of upland hardwoods is being converted to pine, but little is known of the hydrologic effects of this practice. After suitable calibration, the three watersheds will be used in a study to determine the hydrologic effects of converting unproductive upland hardwood stands to pine.

The shallow loessial soils in this study are similar to the soils on the three watersheds previously installed on abandoned old fields. Instrumentation is also the same as on the old-field watersheds and has been described in previous reports.

The initial tiers of electrical soil moisture units were installed in March--one tier on one of the old-field watersheds and one on a watershed with a cover of depleted upland hardwoods. Arrangements have been made to have the soils mapped in detail on the first six watersheds during October. After the detailed soil survey is completed, gravimetric sampling plots will be established on each of the soil types represented. An attempt will be made to correlate data from these plots to the electrical measurements in order to obtain a running record of soil moisture for the entire watershed area. Thornethwaite's and Penmen's formulas for calculating potential evapotranspiration and the soil moisture prediction method developed at Vicksburg will also be tested for application to local conditions. If initial results are promising, additional moisture units may be installed at the shallower depths on all watersheds. This should prove to be one of the most interesting aspects of our work.

...ext battery of watersheds will be installed on pine plantations planted on abandoned eroded old fields. Three small natural catchments with a cover of 20-year-old loblolly pine were located on the Holly Springs National Forest and construction was started early in September. The areas were selected after field examination of some 50 shortleaf and loblolly plantations established on the Forest during the period 1935 - 1943. The small two- to three-acre drainage areas were planted on what were severely eroding and gullied old fields. The pine has grown surprisingly well and has protected the site with a mat of pine litter.

During the field reconnaissance, we were impressed with two observations. Of interest and possible application and significance was the apparent relation between parent material and site index. As the search for watersheds progressed, a broad division of soils--Coastal Plain parent materials vs. soils derived from loess deposits--could usually be determined merely by looking at the pine stands. Both height and vigor of the trees was better on Coastal Plain parent material than on loess. This was especially conspicuous in plantations where the two general soil groups were intermingled.

The other general observation fully confirmed the desirability of the preference of loblolly over shortleaf for erosion control in this area. The growth, and especially the quantity and distribution of ground litter, was far superior under the loblolly.

Instrumentation.--The importance of accurate areal precipitation records on watershed studies is paramount, especially with work involving the water equation. The best way to obtain these records is with an adequate network of raingages. Standard raingages, however, are expensive. Hamilton, Reimann, and Andrews1/ reduced the cost of the gages by eliminating the inner brass tube and measuring the rainfall in lucite cylinders graduated in inches of rainfall. Berry and Berg2/ ingeniously substituted ... can for standard raingages. Other modified gages include the smaller direct reading test-tube-type gages. The accuracy of the substitute gages as compared to the standard has not been fully tested.

1/ Hamilton, E. L., Reimann, L. F., and Andrews, L. A. 1952. Shock resistant lucite graduate. California Forest and Range Experiment Station, U. S. Forest Service, Misc. Paper No. 9, 3 pp., illus.

2/ Berry, Dick, and Berg, Allan B. 1955. An inexpensive raingage. Oregon State Board of Forestry. Research Note No. 23. 4 pp., illus.

During April, about 100 of the No. 10 cans were made up (at a cost of a few cents a can) to supplement the standard raingages on the small watersheds and for use in future interception studies. As a check on their accuracy, eight of the cans were mounted along with two standard gages and records kept since mid-April. While the data have not been analyzed, we are well satisfied that the No. 10 cans are sufficiently accurate to supplement the standard raingages and thus provide a better estimate of areal rainfall.

Another problem was evaporation from the float wells on the H-type flumes. After we were satisfied that the wells filled up quickly upon the onset of flow, float stops were made and installed so that the recording ink line would not dip below the base line on the hydrograph chart. This has helped avoid confusion, improved accuracy, and saved considerable time in tabulating the hydrograph charts.

Planting Studies

The tree planting studies concerned with establishment of cover on adverse sites were reported in detail in the last report. Since only routine measurements have been added during the last six months, discussion of these studies will be deferred until the next report. Fall measurements for the planting studies are scheduled for October.

Soils and Soil Moisture Studies

Moisture and growth changes with thinning.--The field work on this study was completed in August. The data is now being analyzed to determine the changes in soil moisture content and tree radial growth associated with plantation thinning.

Grasses and legumes for erosion control.--Undisturbed soil cores will be taken on the study blocks this winter to determine the effect of the grass plantings on the site. Weeping lovegrass (Eragrostis curvula) continues to be the most successful species used in this test, and on several blocks is escaping to other plots. Switch grass (Panicum virgatum) is the second best grass used in this study.

Fall measurements are scheduled for all the other soils studies during the month of October.

Central Ozarks Research Center

The uplands of north Arkansas include several millions of acres in "problem areas." Most of these were classed as commercial forest area by the Forest Survey because they have yielded commercial quantities of timber in the past, and appear capable of producing these yields in the future, even on sites where timber

growth is poor. By contrast, the National Soils Survey, geared to definitions of the Soil Conservation Service in regard to land use capability, has judged that this forest land is incapable of producing timber in commercial quantities.

Federal subsidies have been proposed to aid farmers to convert this land from forest to range. The first such proposals were put forth in 1950, and in 1957, approval for subsidies was granted on a pilot basis.

It is apparent that basic soils and hydrologic questions regarding wholesale conversion of large areas from forest to range cover and subsequent grazing can only be answered through systematic research. The Central Ozarks Research Center, in cooperation with the University of Arkansas, has instituted a project designed to investigate the hydrologic and economic effects of such conversion.

In one study, runoff plots under two intensities of control grazing as well as undergrazed woodland and undisturbed woodland conditions were established during the summer of 1957, and will be activated shortly.

The hydrologic changes of the surface soil associated with forest to range conversion will be investigated in another study presently being installed. In this study, conversion and grazing effects are being measured on in place infiltration and on physical soil properties.